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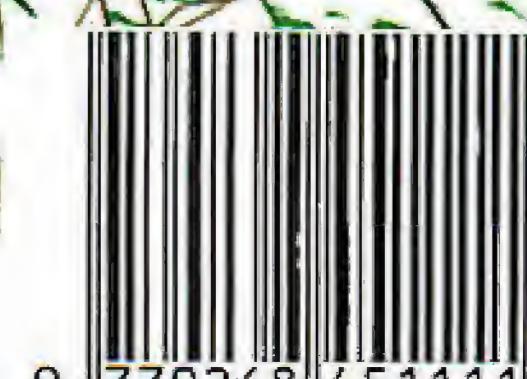
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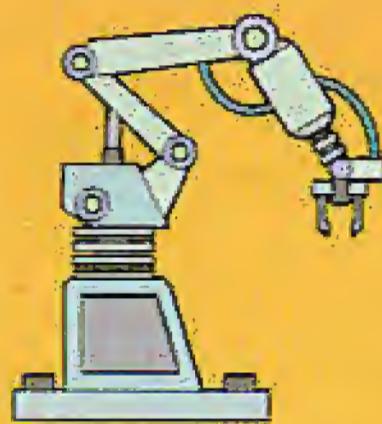
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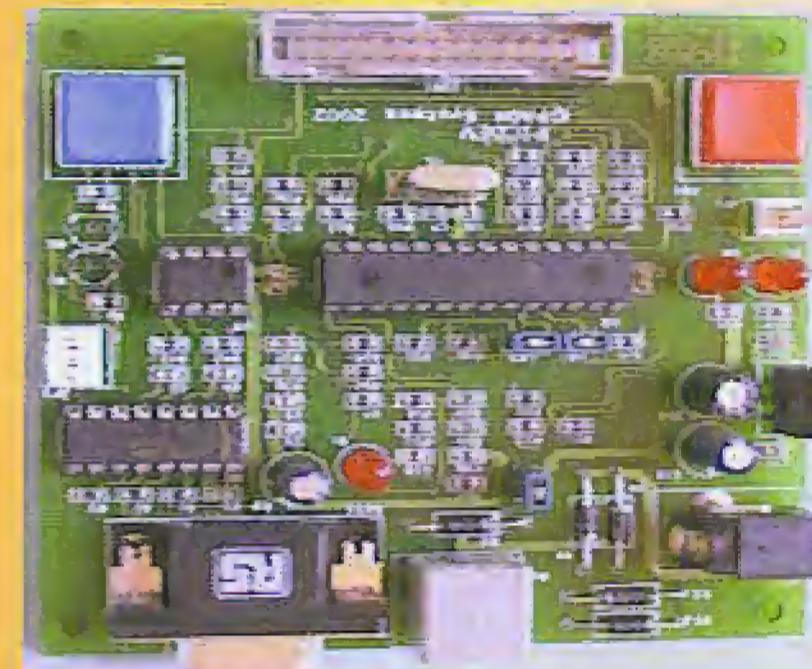
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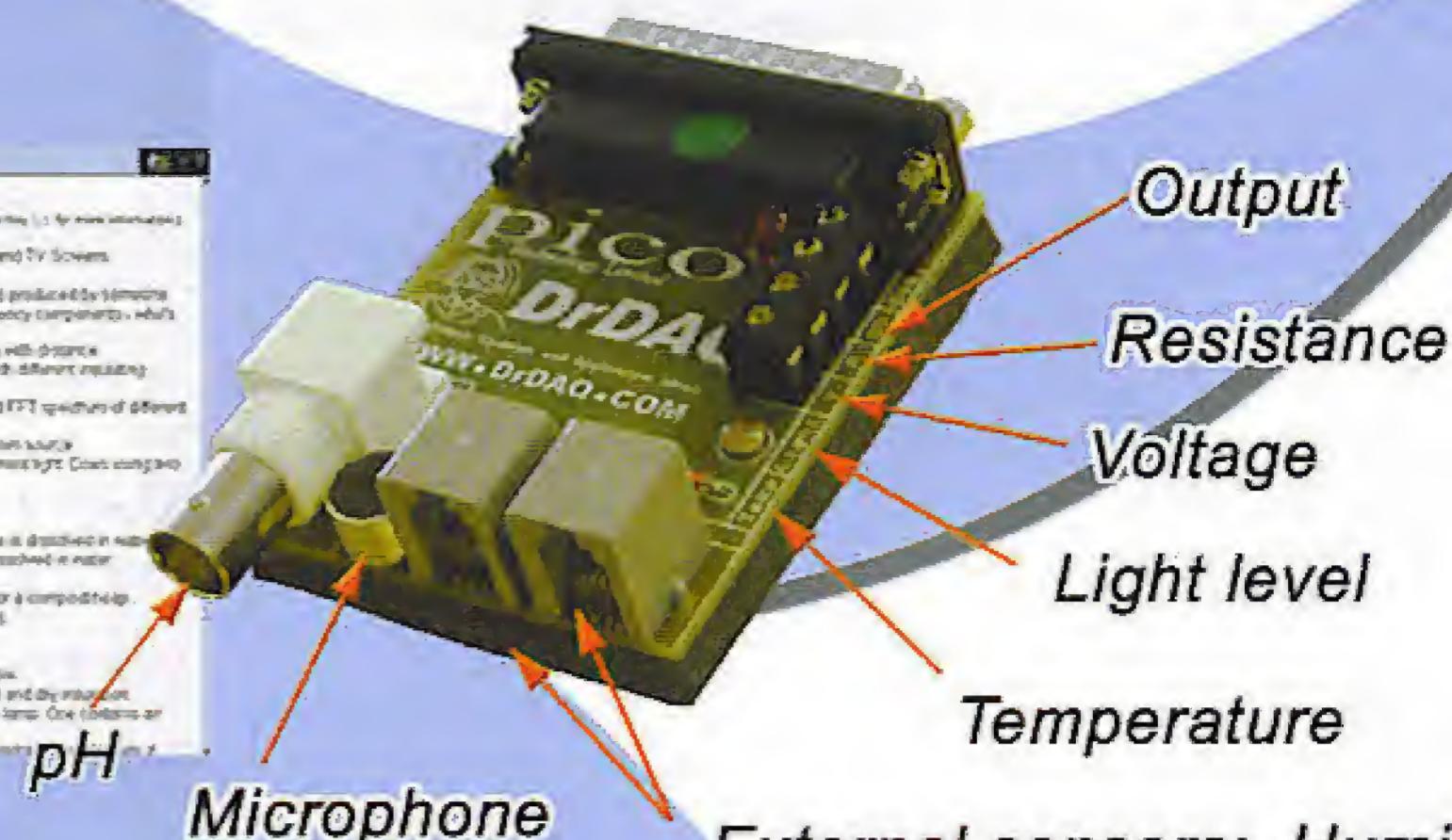
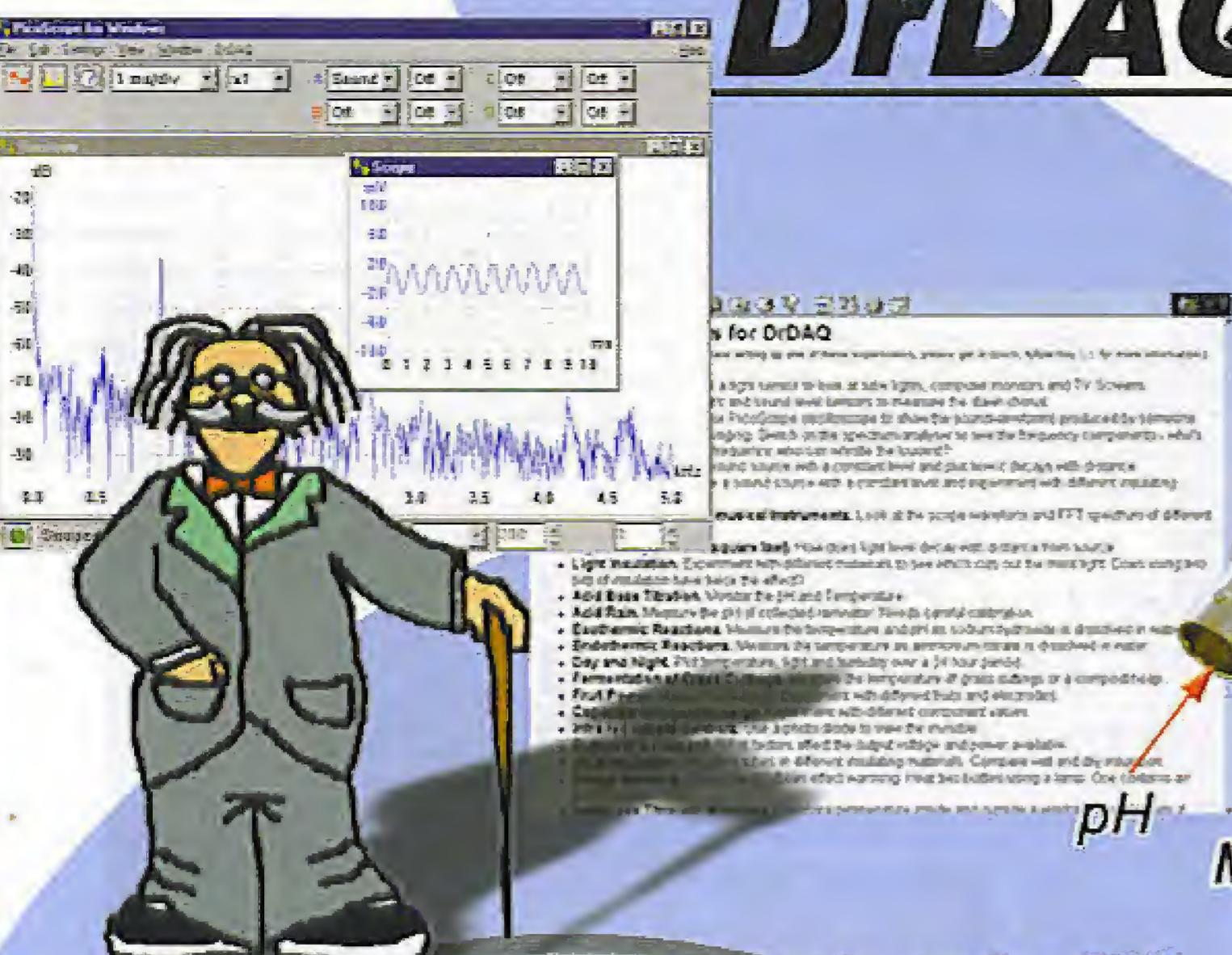
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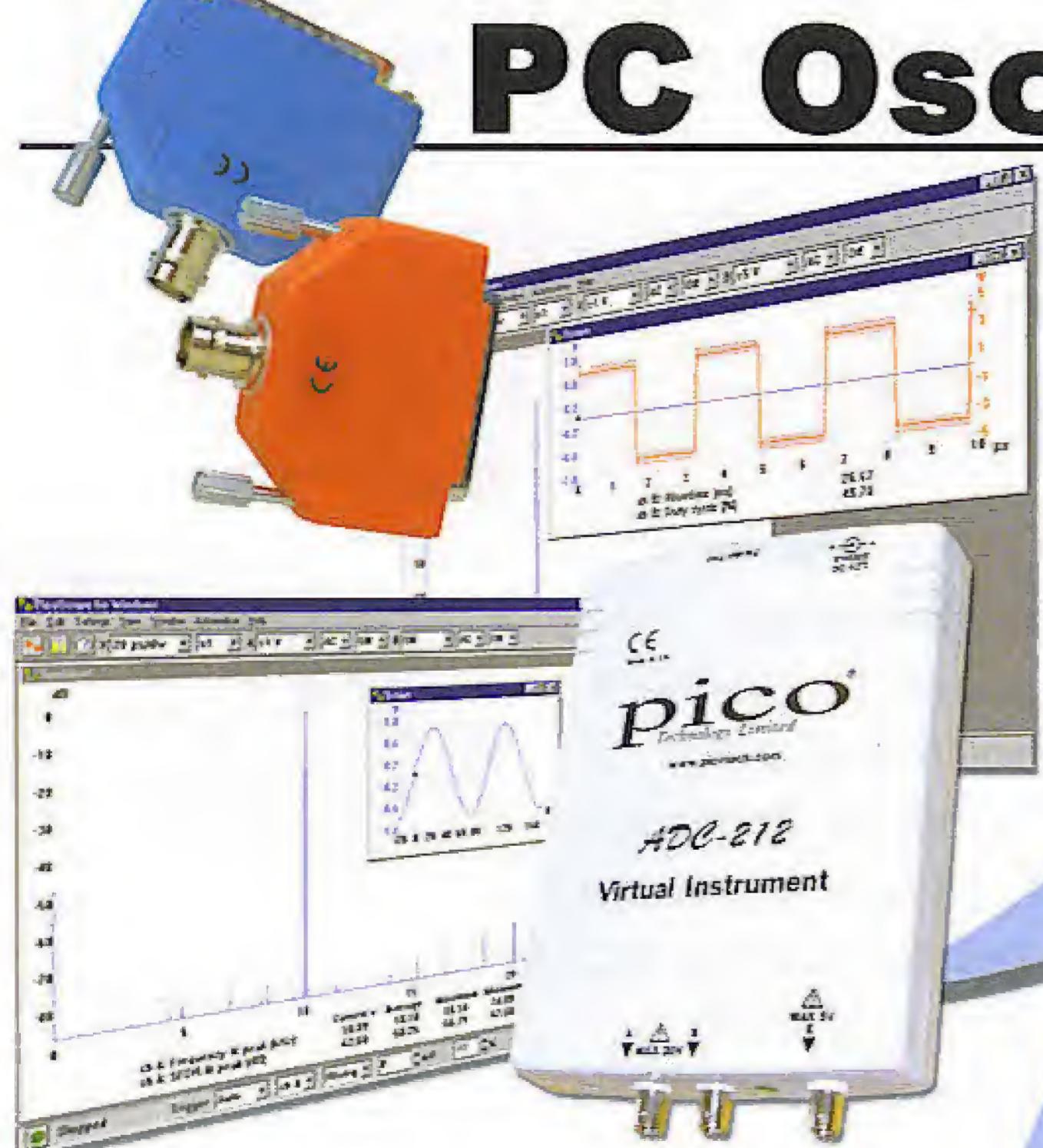
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# Components

From the mass of emails we get with comment on the component selection in our published circuits we can only conclude that many of you think along with us. In many cases, the components referred to are no longer available from local retailers (if they still exist). Both in the industry and the retail trade, the distribution of electronic parts has changed radically over the past few years.

Apart from lots of standard parts Elektor also employs (relative) newcomers to the market. We do this whenever we feel a new part represents a better solution to a problem than one that's been around for some time, or, indeed, can be classified as an 'old-timer'. After all, our readers are interested in better solutions while at the same time learning about the latest developments. On the down side, components may not be available locally anymore as on-offs.

These days, people can buy nearly everything on the Internet. All known electronics mail order companies and distributors can be reached via the web and in general supply at very short notice. Looking at the trends on the web, it appears that new on-line electronics shops pop up every day. Likewise, you can now watch all the leading semiconductor manufacturers set up on-line shops with a direct supply line right down to individual customers. Now isn't that shopping paradise for electronic parts?

Not so, apparently. We receive lots of complaints about minimum order quantities and shipping charges. The latter I find a bit surprising considering the cost of fuel and parking tickets if you use your car to get to a retail store. On the other hand, I too have to admit to hesitation if I really would like to order something but the small print says £3.50 for postage and packing. However, such doubts are not rational. If you drink a pint in the pub, surely you do not spoil the fun by thinking that the same amount of money could have bought you five times as much canned beer at the supermarket?

The moral of my story: we have to live with the constraints imposed by the changed distribution of electronic components. However, I am convinced that we now have access to far more and more modern parts than in the past. Make clever use of it and do not be put off by the changed price structure.

Karel Walraven, Head of Design Department



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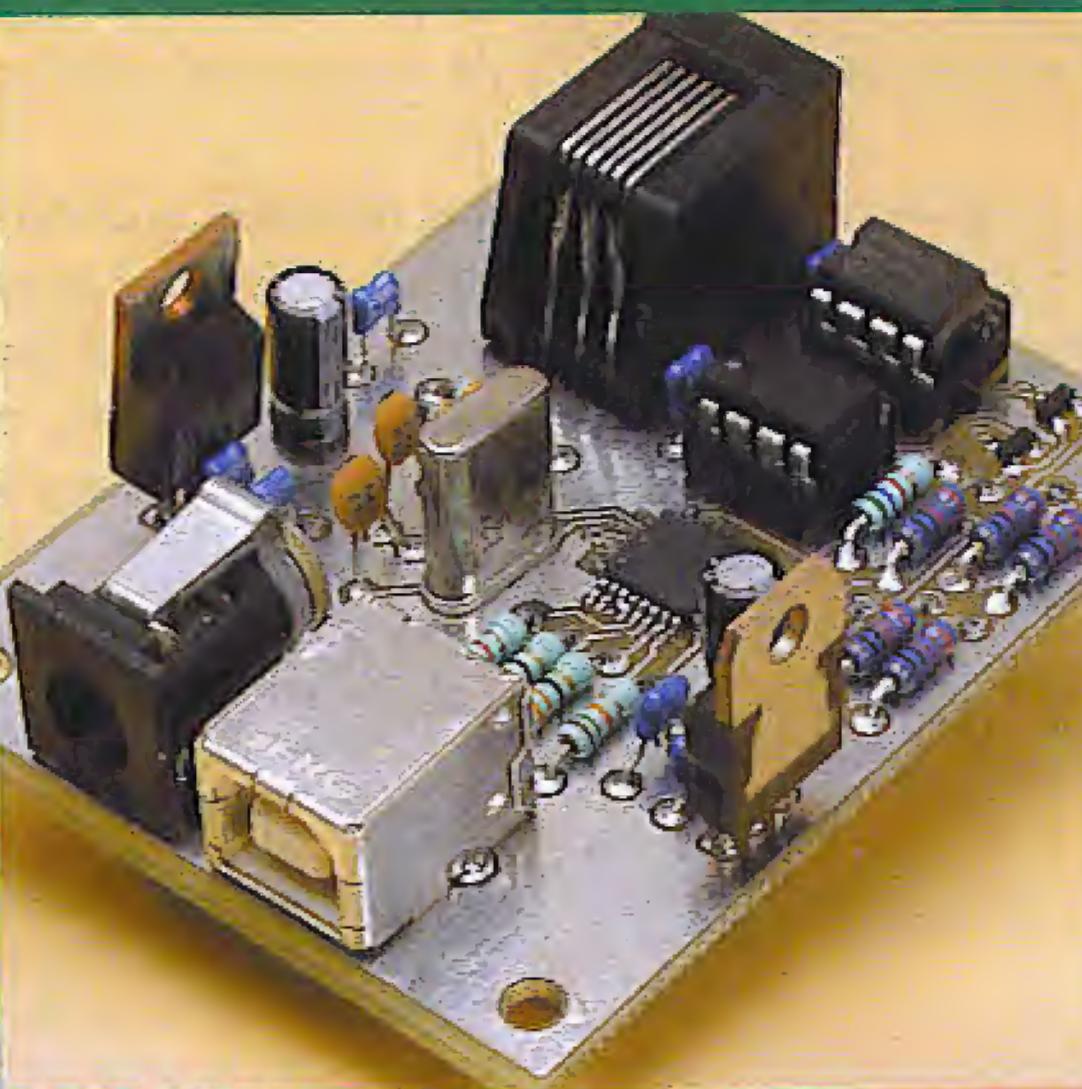
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### On the Buses

Home automation does not stop at remote control for audio & video equipment. Although an increasing number of manufacturers jump the bandwagons called Home Automation and Smart Home, there are no signs as yet of a real breakthrough 'for the millions'.

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### I2C / USB Interface

The I2C bus has been used many times to provide a simple connection between a PC and home-built circuits. This often made use of a simple interface connected to the parallel port of the PC. This now seems a bit dated, so we've designed a USB/I2C interface for you to build.

72



### LED Christmas Tree

This flashing LED mini Christmas tree is not only dead simple to build but the design is also repeatable and very reliable in operation. In fact an ideal last-minute project to brighten up the house or office in the run-up to Christmas.

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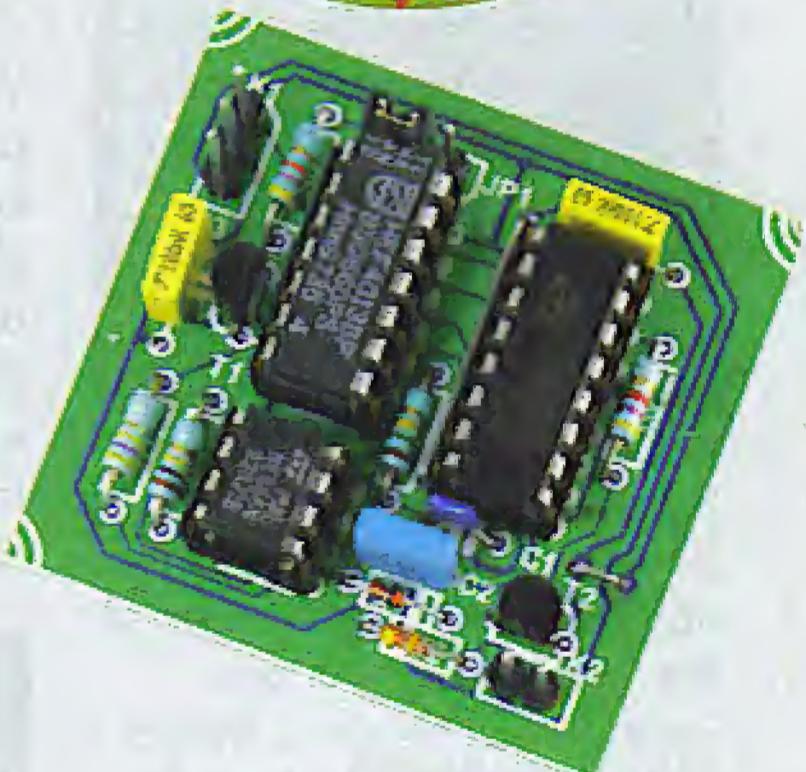
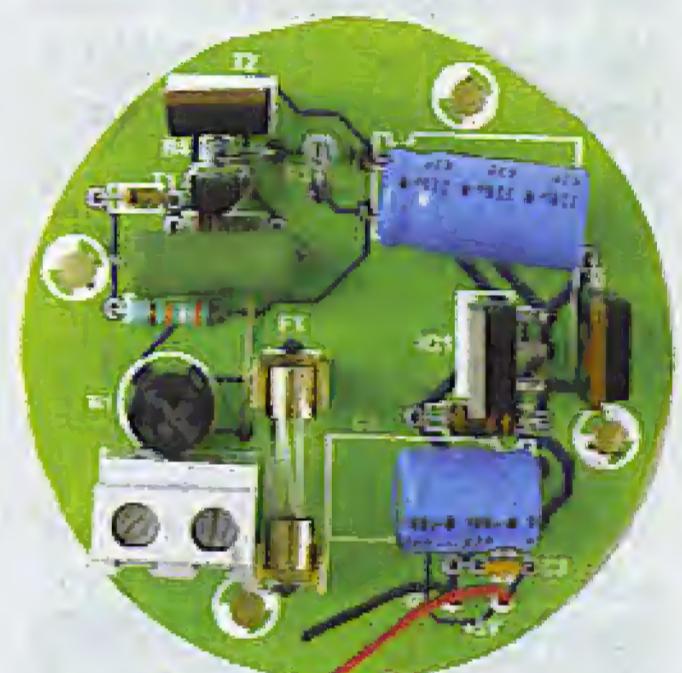
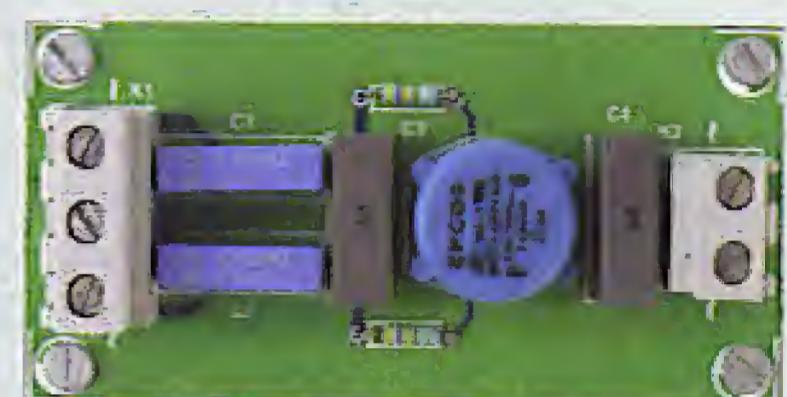
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**Bold article title** = includes PCB layout



## Construction Projects

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	Power Supply for USB Devices
72	kitchen table: LED Christmas Tree

We thank all our readers and advertisers for their continued support during the past year and wish them a happy and peaceful 2005.



**Message from South Africa** Dear Jan — in the April 1980 issue, which was devoted to Automotive Electronics, Elektor published an 'Intelligent Windscreen Wiper Delay' circuit. This used about 8 ICs, not least of which was a 21L02 memory! I built two of these over the years, and it was quite the cleverest and most useful device of its type I have ever encountered. The only change I made was to extend the delay cycle to up to about 4 minutes — very handy in my country where we don't get a lot of rain! Unhappily, many of the devices needed are no longer available, not least the 21L02. Even getting the original ones was a problem — I had to go all the way to a side-street electronics shop in New York City to find them! I know you published a sort of update a few years back, and I have the article in my files somewhere, but as I recall it didn't do quite what the original had done. And in any case it too is probably out of date by now. So my question is this — is it possible that you might come up with a 'modern' version of the 1980 design? It can probably all be done with a single PIC IC these days, for all I know!

I think the new Elektor style and layout is just great! Not that there was much wrong with the old one.

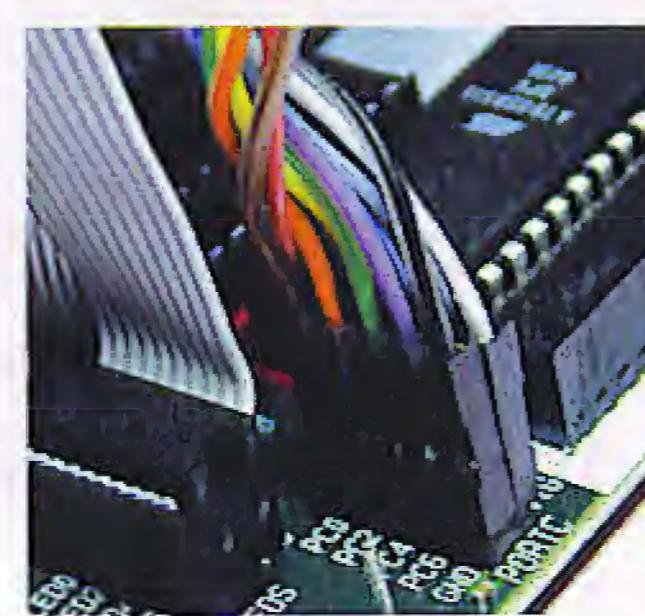
**Chris Graham  
(South Africa)**

*It's wonderful to see how readers of this magazine cherish designs published so long ago they are no longer remembered by anyone on our current staff.*

*A possible source for (long obsolete) RAM chips like the 21L02 are the spare parts suppliers serving the vintage pinball machine and arcade game communities.*

*I'm sure the Internet will enable you to get in touch with a trader. Your request for a PIC based windscreen wiper control has been copied into our design lab. Sometime next year we will publish an issue focusing on automotive electronics and maybe a suitable design is ready by then.*

**Connector parts** Dear Sir — I've been an avid reader of Elektor since I was a young lad the mid 70's. I've followed the changes in style and presentation over the years and must agree that the present new look is an improvement, if one can improve on perfection! The two photos of some single wire connectors illustrate the problem I am having. What I am trying to find is single connectors like those in the two photos, on a 0.1" pitch. These can be connected to flying leads and plugged up to 0.1" headers as illustrated in any combination so desired. I know they exist, since most PC's use them to connect case front switches, USB ports and



other case hardware. But try as I might, and I've phoned quite a few manufacturers as well as the usual suppliers (Farnell, RS, Maplin) I can not find these receptacles in single format. The ones featured in the photos were made by cutting up multiway blocks and filing them down, a time (and nail) consuming task.

Do you know where on earth I can get my hands on some of these. I know of several other users of Atmel boards who would like some as well. Any ideas, please?

**Richard Austin**

*Readers having information that could help Mr. Austin are requested to contact the Editor. Meanwhile, Luc Lemmens from the Elektor lab tells me single 0.1-inch pitch receptacles can be cut off strips of the type shown in the photograph.*



*As there is no clamping mechanism, the wire end needs to be soldered and then protected using heat shrink sleeving.*

**Probing around** Dear Editor — recently I had a problem here at work, monitoring high frequency digital quartz clock oscillators. I needed to adjust each crystal loading capacitance and absorb the board strays to bring the frequency in tolerance. Some of our crystals are accurate to 15 ppm and the highest frequency is 54 MHz.

Without thinking enough I had used a Tektronix 500-MHz, 10x passive scope probe feeding an 8-digit 200-MHz frequency counter. For accuracy I used a Quartzlock Off-Air standard to give me a precision 10 MHz reference source for the counter traceable to NPL. However I didn't spot the 8-pF loading of the scope probe! Consequently my results did not agree with our RF team who used their Agilent 89441A Vector Signal Analyser with a 'sniffer lead' held in the vicinity of each clock circuit. Hence their loading of each oscillator was negligible, resulting in my readings being around 20 ppm too low! Problem resolved by using a new Tektronix TDS57704B, 4-channel digital scope. This gear happened to be in the lab on evaluation. Tektronix have wisely brought out one of the 4-channel analogue signals (prior to digitisation) to the front panel. I was then able to use one of their active FET probes and connect the frequency meter to the scope analogue output. Hence around £ 40k of active probe!

This resulted in the loading error compared to our RF team's measurement closing to around 5 ppm worse case. An alternative to tying up the 4-channel digital scope was to use an Agilent 3-GHz active RF probe, adding an N-type to BNC adapter to its rear and power it from any Agilent spectrum analyser. At this point I started thinking off build or buy for a stand alone very low capacitance active probe. I found few on the market with less than 1 pF input capacitance! The ones that are, are made by Tektronix, LeCroy etc. for their own scopes, designed to plug into a specialised

front panel connector which provides signal and probe power. Tektronix have discontinued making a bench supply to use their probes stand alone. Sigh!

Imagine my amusement then, in finding David Jewsbury's article last Saturday ('Poor Man's 1-GHz Probe', October 2004, Ed.), while perusing the few electronics mags in WHSmith's.

I was just beginning to think of reaching for my soldering iron to grow my own low cap probe. I will build his circuit with a follower second stage as I don't need the bandwidth but just the low input capacitance.

All the best with your excellent magazine.

**Alan Bate**



Thanks Alan for this example of how a complex problem is tackled in your work environment. Here's proof that the subtitle with our article: 'DIY saves a pretty penny' was spot on.

### Happy Birthday

Dear Sirs — I have been reading Elektor from the start and have found your maga-

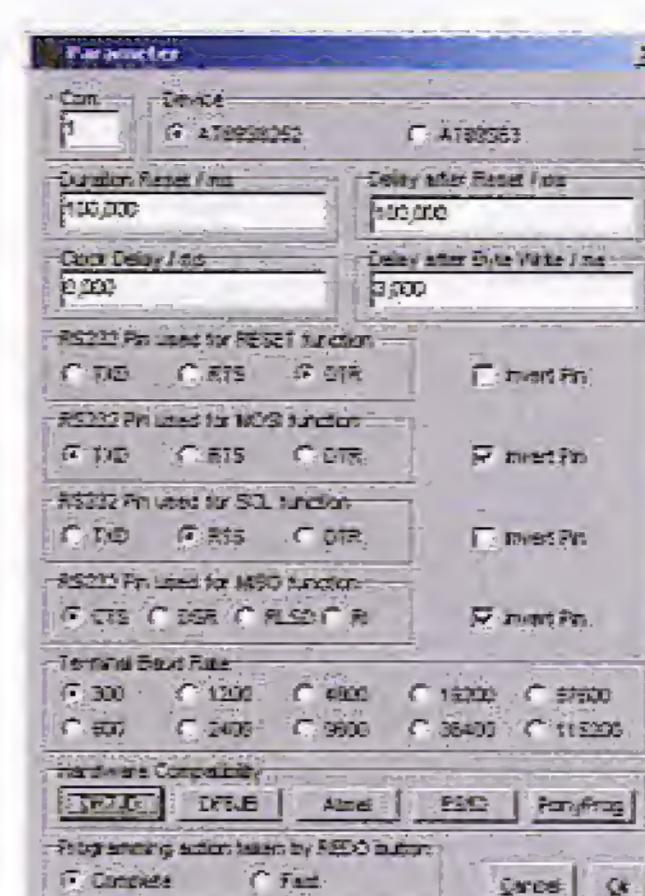
zine to be a wonderful font of knowledge. I am sure I am not alone in wanting to thank you, for helping me over the years with design ideas etc. I have every edition from about 1980 onwards (squirrels in the loft destroyed my earlier volumes). I wondered what joys you will be bringing us on your thirtieth birthday. Happy Birthday Elektor! **Mark Scottford (Spain)**

*Readers wishing to part with pre-1980 copies of Elektor magazine, or complete year volumes please contact the Editor for Mr. Scottford's contact details. As to the joys of this month, I sincerely hope they start on page 11!*

**Flash Micro Board vs. fast PC** Dear Elektor staff — I have been using your 89S8252 Flash Micro Board (December 2001, Ed.) for about two years with great pleasure, having managed to link it to a couple of applications like A/D, D/A and system controls.

However since starting out with the project (in 2002) I've had recurring problems with the downloading of programs. After a few experiments it transpired that my 2.8-GHz PC did not work properly with the MicroFlash utility, whereas an old 433-MHz machine worked a treat. A few days ago I repeated the test with the same result: communication problems when downloading programs from the fast PC. Is a workaround available? **Bram Vooys (Netherlands)**

*We were surprised to read of your problems considering that thousands of Flash Micro Boards have been sold since December 2001. There is a solution: use a utility called ATMEISP, you can*



find it at, among others, [www.modul-bus.de/mbnews/mbnews02/isp.htm](http://www.modul-bus.de/mbnews/mbnews02/isp.htm).

Open the 'parameter' menu in the top left-hand corner of the screen; next select the COM port and then DK7JD.

(Mr. Vooys has since advised us by email that this solution worked perfectly, Ed.) [screendump 045080-62]

### Lost & Found

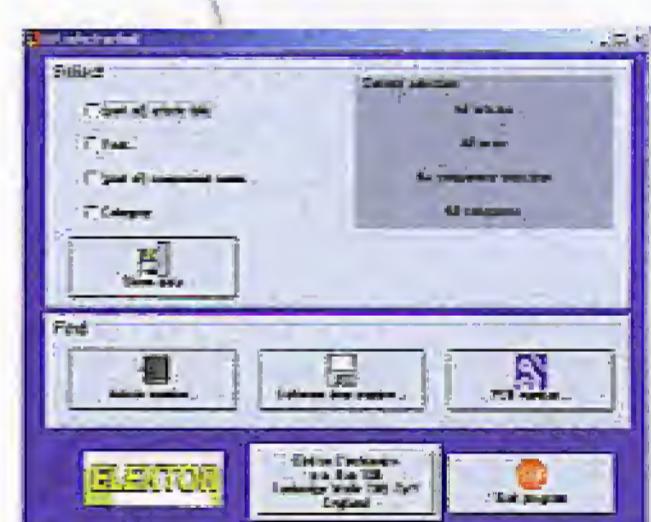
Dear Editor — A short time ago, a friend brought to me a power supply which, he said, I had made for him some years ago. Frankly, I have no recollection of so doing but it bore all the hallmarks of my mechanical handywork. I accepted that what he said was true. He had connected the PSU the wrong way around to a battery. It no longer worked; would I repair it? Clearly, it was an EE project. But when was it published? The only clue was the code mark on the PCB. I sent this to you and asked if the year of publication, at any rate, could be given.

Within days, a reply came giving the year, date and page number. I looked up the article and have been able to repair the damage (blown track and a

projection diode shorted). Again, thank you for your excellent service. I continue to enjoy your magazine and like the new format.

**Edward Benson, G3MUX**

*Credit is due to our Editorial Secretariat who traced the PCB number (980024-1) to the respective article ('Variable Power Supply', March 1998). Anyone can do this, however. Finding past articles by production number, PCB and/or software item number has been a standard feature of our EIT (Elektor Item Tracer) for over 10 years as well as of the search engine implemented in our year volume CD-ROMs as of 2003. Both products should prove extremely useful to owners of complete year volumes of our magazine. The EIT starts at 1985, the CD-ROM engine at 1996.*



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## Diagnostics and Development Tools for SMBus and I<sup>2</sup>C

AVIT Research Ltd. has released a low cost I<sup>2</sup>C Bus Tool for the diagnostic and development of embedded system SMBus and I<sup>2</sup>C communications. The Tool combines ease of use with comprehensive facilities to monitor bus activity and powerful functionality for participating on the bus. Messages can be sent and received as either Master or Slave on Standard and Fast Mode Busses. The I<sup>2</sup>C Bus Tool complements AVIT Research's existing I<sup>2</sup>C Bus Monitor and RS232 products.

The I<sup>2</sup>C Bus Tool provides a simple means of examining and interacting with bus traffic on an I<sup>2</sup>C or SMBus system using a standard PC — without the need for external power supplies or the installation of driver software. It provides a user interface via the HyperTerminal application (supplied with Windows). This interface allows messages to be composed and sent when acting as a bus master and to receive data from slave devices through the master receive function. The interface also allows the I<sup>2</sup>C Tool to be configured to act as an I<sup>2</sup>C slave device to

automatically receive data and respond to requests for data from Master devices on the bus. I<sup>2</sup>C messages can be colour coded according to the I<sup>2</sup>C device address and timestamps can show the time of each message with a resolution of 1ms. Filters can be applied so that only messages for devices of interest are shown.

The supplied Windows Software Development Kit (SDK) provides an alternative to the HyperTerminal interface for writing custom software using VB, VBA, C/C++, Delphi or Java. The SDK gives the programmer access to all the functionality of the I<sup>2</sup>C Bus Tool and using this it is possible to emulate slave devices such as EEPROMs, ADCs and DACs. Example code and applications are included. The Trigger connection allows an oscilloscope to be triggered in reaction to a sequence of bytes on the bus or to act as an input where transitions on the probe are shown as time-stamped events within the I<sup>2</sup>C data. The I<sup>2</sup>C Bus Tool is packaged as a standard size 9-pin D-Type connector suitable for connecting to a PC serial port. It is supplied

with approximately 0.6 m of cable with four probe clips for connection to the I<sup>2</sup>C system. The connections are Ground, I<sup>2</sup>C Clock, I<sup>2</sup>C Data and Trigger.

### Features:

- Monitors bus traffic on SMBus\* or I<sup>2</sup>C systems at up to 400 kHz (Fast-Mode).
- Master Transmit and Receive including Repeated Start Requests.
- Slave Emulation – Slave Transmit and Receive (Ack of Data bytes).
- Multi-Master Bus Compatible.
- Trigger Line provides an output to an oscilloscope or can be set to an input for timing events.
- Shows acknowledgements (ACKs) and negative acknowledgements (NACKs).
- Connects to standard PC serial port or USB to serial adapter.
- No power supply required.
- Compatible with 5 volt and 3.3 volt Buses.
- Compact; all circuitry is integrated within the D-Type connector.
- Can be used with standard terminal programs supplied with Windows or Linux.



– Supplied with Windows Software Developer Kit that provides I<sup>2</sup>C functionality to VB, VBA, C/C++, Delphi or Java applications through an OCX. Help and Example Code included.

The I<sup>2</sup>C Bus Tool including Windows SDK is available directly from AVIT Research at **only £ 250.00**.

**AVIT Research Ltd.**, Compass House, Histon, Cambridge. CB4 9AD.  
Tel: (+44) (0)1223 257758,  
Fax (+44) (0)7092 111293.  
Email: i2c@avitresearch.co.uk  
Website: www.avitresearch.co.uk

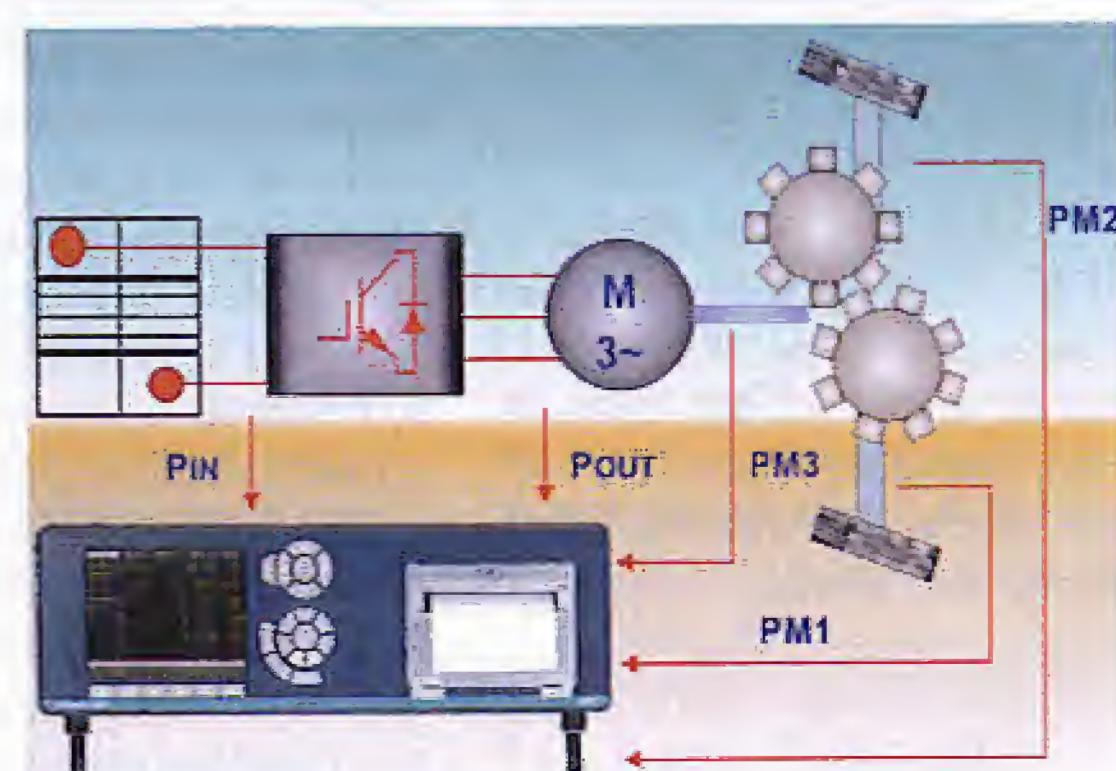
(D47199-5)

## Process Interface for Electrical Drives

LEM has introduced the PI1 process interface for its NORMA power analyser family. The interface allows measurement of up to four speeds and torques simultaneously, quickly and precisely, and can calculate the mechanical power. The NORMA analyser measures the respective electrical power for the calculation of the efficiency under dynamic conditions.

It is not enough to measure the efficiency in a steady state, because the biggest losses usually occur during the starting and stopping phases of the drive. Therefore electrical and

mechanical power values must be measured very quickly and, above all, simultaneously. This can be achieved with LEM's NORMA 3000, NORMA 4000 and NORMA 5000 analysers. Mechanical powers are sampled at 34 kHz; electrical values at either 11.3 kHz, 340 kHz or 1.02 MHz, according to the model. Through the eight inputs for mechanical values, the system can measure multiple motor systems or conduct measurements before and after transmissions. The efficiency can, therefore, be measured with a single measuring instrument.



**LEM HEME Ltd.**,  
1 Penketh Place, West Pimbo,  
Skelmersdale,  
Lancashire WN8 9QX.

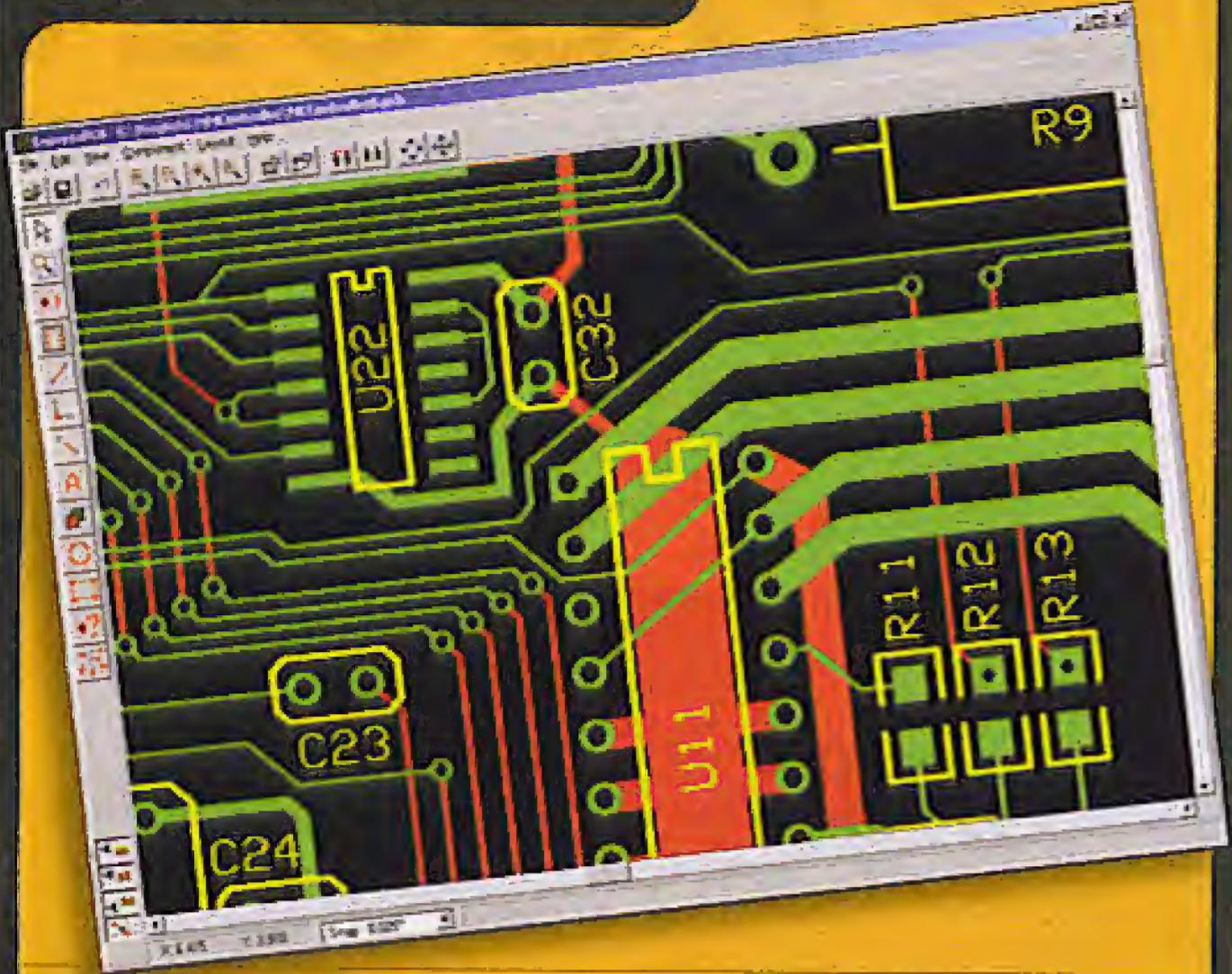
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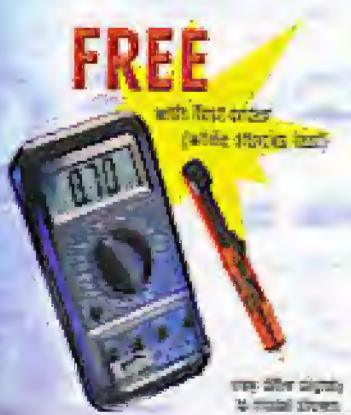
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# ON THE BUSES

**David Daamen**



Being able to control a TV or a stereo from the comfy chair is taken for granted these days. However, home automation does not stop at remote control for audio & video equipment. Although an increasing number of manufacturers jump the bandwagon called Home Automation or even the Smart Home, there are no signs as yet of a real breakthrough 'for the millions'.

Although several systems are currently available on the market to automate various functions in and around the home, the large number of different, competing, standards and proprietary developments is a large stumbling block on the road towards the Home of the Future.

In an earlier issue we wrote that developments in home automation were being slowed down by the possibilities and impossibilities of facility engineering ('Home Bus Systems', *Elektor Electronics* February 2001). Apparently, developing and marketing a compatible system is time

# Last station still far off

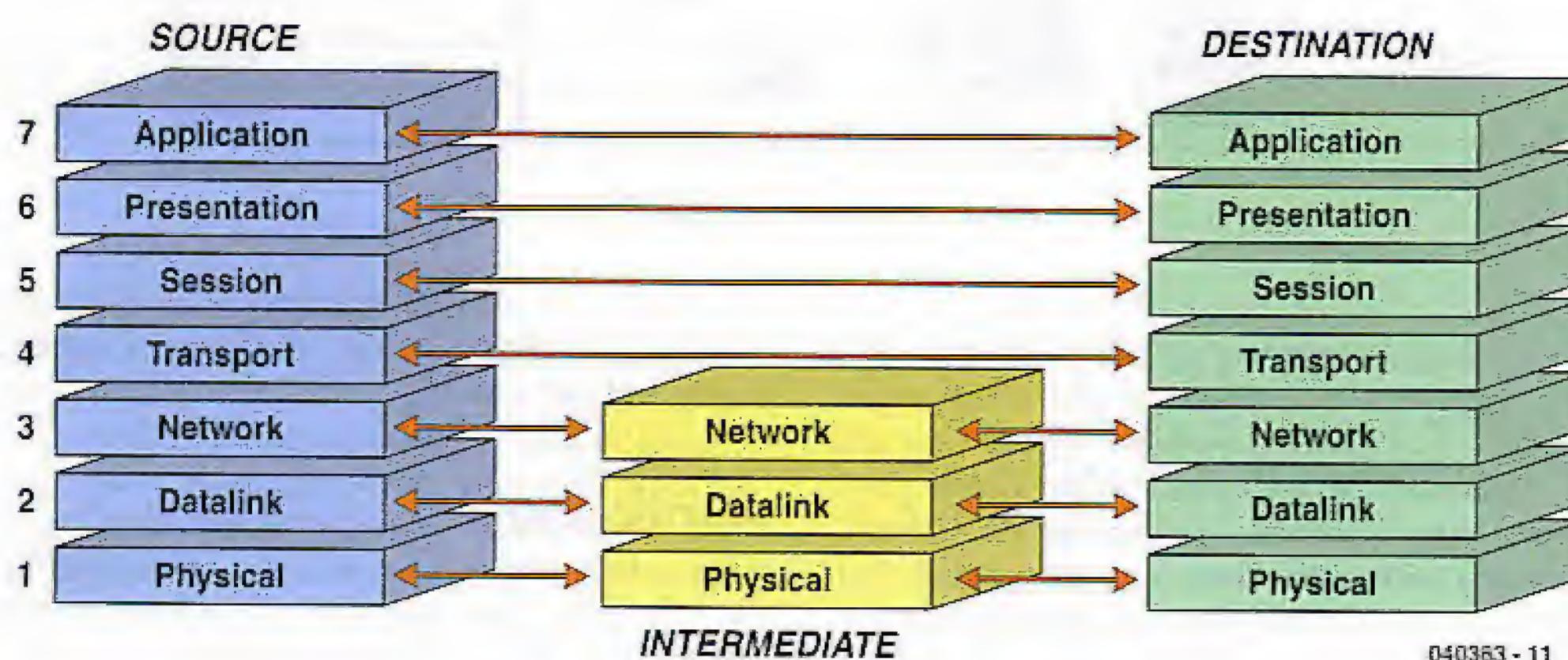


Figure 1.  
The Open Systems  
Interconnect (OSI)  
model developed by  
the ISO.

consuming to the extent that manufacturers are always one step behind reality.

One of the main problems seems to be flaky exchange of data between different applications. Once the main hitches have been recognised, it is often impossible to make amends at the high pace that rules in the electronics industry. This situation has resulted in a plethora of different protocols and standards which only seems to aggravate the problem.

Lessons have been learned, however, because today the trend is not just to look at the connection method, but increasingly at the actual application.

## OSI

The fact that it has taken so long for the system designers to spend time on the application is not surprising in itself. Since the mid-1980s, there exists a standard describing the aspects to take into account when implementing the network functionality. At that time, the ISO (International Standards Organization) published a reference model called *Open Systems Interconnect (OSI)*, see **Figure 1**. A bit further on, we'll see that besides many standards concentrating on the actual connection and/or the manner of communicating, there are now also standards giving due attention to the highest layers of the OSI model: the area where the actual application is concerned. For convenience's sake, we will divide the standards (professional networking and home automation) into three categories derived from the OSI reference model. The subdivision is into (1) the network layer; (2) the communication layer and (3) the application layer.

## Networking

Standards like RS-485, Ethernet, FireWire, HomePNA,

HomePlug, MoCA, USB and X10 are primarily descriptions of ways to communicate over a physical medium. HomePNA, for instance, is a standard with widespread use in the USA, describing how connections with speeds up to 240 Mbit/s can be established within the home using the (existing) telephone wiring. The *Multimedia over Coax Alliance* has published a standard based on the same principle: making use of existing cabling — in this case, coax cabling already installed in many homes for the distribution of (analogue) radio and TV signals. According to the MoCA, the standard is future-proof and capable of speeds up to 1 Gbit/s.

The HomePlug standard now 'on the rise' in Europe also employs existing cabling — the mains wiring installed in your home. Speeds up to 14 Mbit/s are said to be within reach.

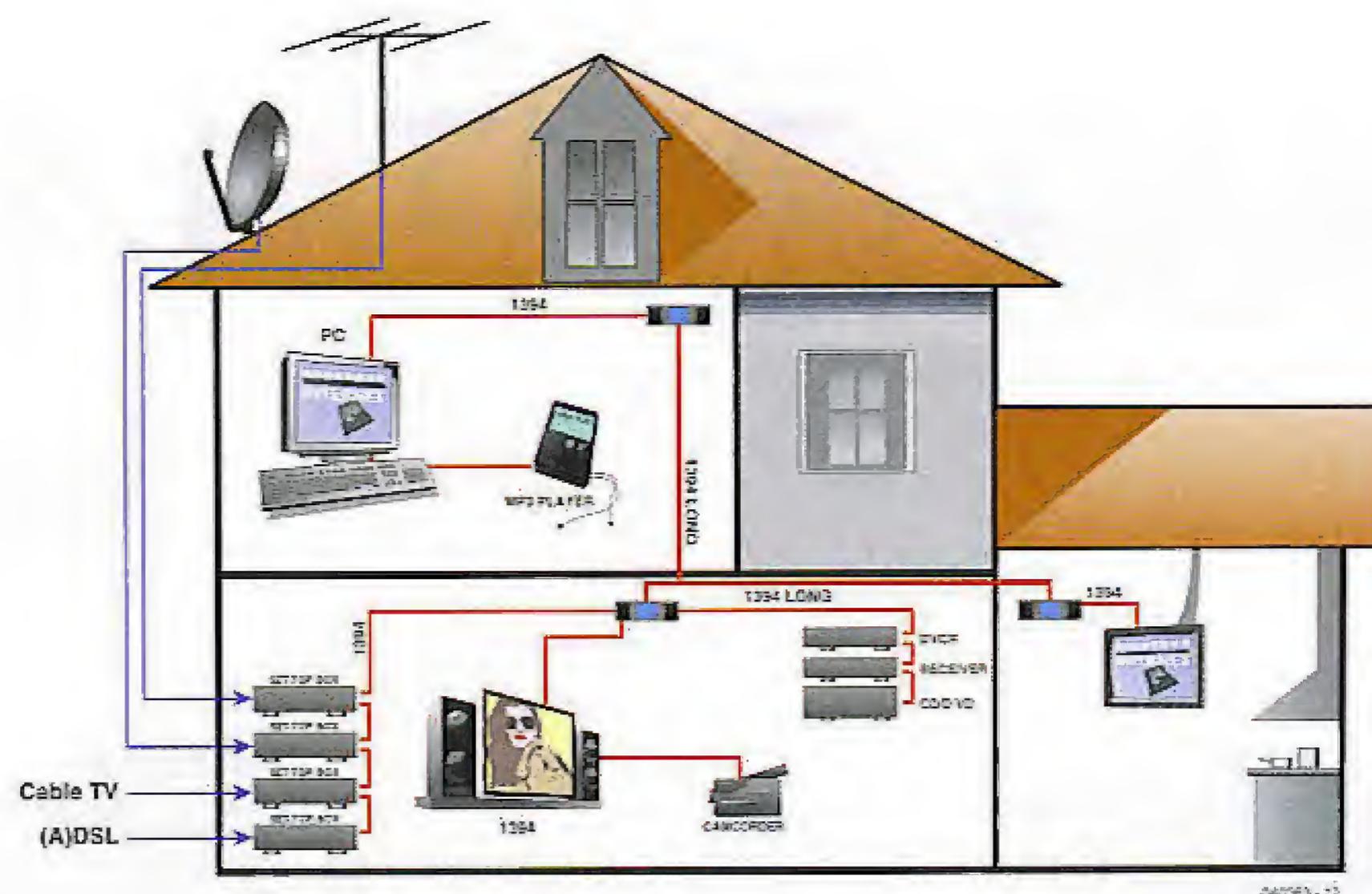
Arguably, wireless standards like Bluetooth, ZigBee, DECT, WiFi and IrDA also belong to the network category. The '**Bus Systems**' inset provides links to more information on all these standards.

In the network layer, the focus is on physical interoperability (connectivity), hence most standards do not go beyond the first layers of the OSI model.

The upshot is that such standards are not terribly useful without agreements on how data is being transmitted and this is where the need for a networking protocol becomes apparent. Today, IP (Internet protocol) is the most frequently used.

## Communication

The comms layer comprises standards like BACnet, Batibus, EIB, EIBA, LonWorks and KNX. The latter will be reverted to below. These are primarily communications systems. The standards describe the data packets travelling up and down the network between machines (ter-



**Figure 2.**  
HAVi is based on a Firewire link for conveying digital audio and video signals.

minals), without a connection having been set up beforehand.

In this context, inter-operability is crucial. One of the ways to achieve it is to agree on a transmission scheme that's not dependent on the data being sent. This will fit in very well in an 'open' system, the protocols being universal and free for use by anyone. Incidentally, a system based on 'open' specifications is eventually closed off its

own accord when it is used in a certain application or configuration!

## Application

Within the standards normally associated with this layer, the emphasis is on system and application management. Consequently, the main aim of the standard is to define a so-called network-independent API (Application Program-

# Bus systems

## Network layer

- RS-485
- IEEE 802.3
- IEEE 1394
- HomePNA
- HomePlug
- MoCA
- USB
- X10
- IEEE 802.15
- ZigBee
- DECT
- IEEE 802.11
- IrDA

- Recommended Standard ANSI/TIA/EIA-485-A-98
- Ethernet
- FireWire
- Home Phoneline Network Alliance
- HomePlug Powerline Alliance
- Multimedia over Coax Alliance
- Universal Serial Bus
- X10 Wireless Technology
- Bluetooth
- ZigBee Alliance
- Digital Enhanced Cordless Telecommunications
- Wireless Fidelity (WiFi) / Wireless LAN
- Infrared Data Association

- [www.tiaonline.org](http://www.tiaonline.org)
- [standards.ieee.org](http://standards.ieee.org)
- [www.apple.com](http://www.apple.com)
- [www.homepna.org](http://www.homepna.org)
- [www.homeplug.org](http://www.homeplug.org)
- [www.mocalliance.org](http://www.mocalliance.org)
- [www.usb.org](http://www.usb.org)
- [www.x10.com](http://www.x10.com)
- [www.bluetooth.com](http://www.bluetooth.com)
- [www.zigbee.org](http://www.zigbee.org)
- [www.dectweb.com](http://www.dectweb.com)
- [www.wi-fi.org](http://www.wi-fi.org)
- [www.irda.org](http://www.irda.org)

## Communication layer

- BACnet
- BatiBUS
- EIB
- KNX
- LonWorks

- Building Automation and Control Networks
- BatiBUS Club International
- European Installation Bus
- Konnex Association
- Local Operating Network Works

- [www.bacnet.org](http://www.bacnet.org)
- [www.batibus.com](http://www.batibus.com)
- [www.eiba.com](http://www.eiba.com)
- [www.konnex.org](http://www.konnex.org)
- [www.echelon.com](http://www.echelon.com)

## Application layer

- CEBus
- Modbus
- PROFIBUS
- HAVi
- EHS
- OSGi/RG
- Salutation
- UPnP

- Consumer Electronics Bus
- Modicon bus
- PROFIBUS International
- Home Audio Video Interoperability
- European Home System
- Open Service Gateway initiative/Residential Gateways
- Salutation Architecture
- Universal Plug and Play

- [www.cebus.org](http://www.cebus.org)
- [www.modbus.org](http://www.modbus.org)
- [www.profibus.com](http://www.profibus.com)
- [www.havi.org](http://www.havi.org)
- [www.smarthomeforum.com](http://www.smarthomeforum.com)
- [www.osgi.org](http://www.osgi.org)
- [www.salutation.org](http://www.salutation.org)
- [www.upnp.org](http://www.upnp.org)

ming Interface). This category comprises standards like CEBUs, ModBus, PROFIBUS, HAVi, EHS, OSGi and UPnP.

Whereas CEBus is used predominantly in the US of A, initiatives like HAVi and UPnP refer to truly global developments. You may already have heard of UPnP, the concept of plug-and-play being familiar from the Windows/PC environment where it is fully integrated in the hardware and software concepts.

For clarity's sake we should mention that there is an amount of overlap in the categories mentioned. For example, certain standards from the network category are often complemented with solutions for management and control. The opposite also applies where a certain medium is sometimes chosen as the basis for an application group. This applies to, for example, HAVi, a system with its roots firmly in Firewire (IEEE1394) and intended as a connection standard for digital audio and video signals (**Figure 2**).

## Konnex

A full discussion of every available standard is unfortunately beyond the scope of this article, hence we will pick out one we think is particularly interesting. The standard proposed by the European Home System Association (ESHA) is a good example of how it should be done. Apart from supplying specifications on medium and communication protocols, the consortium aims at furnishing a solution that's brand-independent, auto-configuring (plug and play), modular and future-proof. The fact that ESHA, Batibus and EIB decide to team up to form the Konnex Association (**Figure 3**) is sure to help achieve the original goals.

Because the standard is open and platform-independent while also supporting various real-world media, we believe it will see increasing coverage in the future.

## In practice

So what does the future hold in respect of home automation system? With a well-founded base approaching rapidly, the possibilities are in principle only limited by our fantasy — or that of the manufacturers, of course. Today's ability to control the TV or stereo rack from the comfy chair is just a harbinger of what we can expect to see in a few years time. Meanwhile we have to make do with remote control lighting systems now available from builders' markets. However, this will not be terribly interesting until other systems are integrated (**Figure 4**). Just think of a voice-controlled computer assisting you with measurement and control functions in and around the home, or the central heating activity linked to a time programmed on an alarm clock. A quarter of an hour before you get up, the domotics system provides a comfortable temperature in the bathroom! Taking this one step further, the coffee machine is switched on automatically when you leave the shower.

Home automation may also contribute significantly to security. For example, in your absence a central system may simulate activity in the home and even text you when an alarm condition arises from intruder, flood, high/low temperature or smoke detection, so you get an alert when you've left the oven on!

## Do it yourself domotics

With consumers waiting for the industry to come up with proper and affordable systems, it is not surprising to see a flood of DIY solutions on the Internet. A couple of these



Figure 3.  
Logo of the  
Konnex Association.

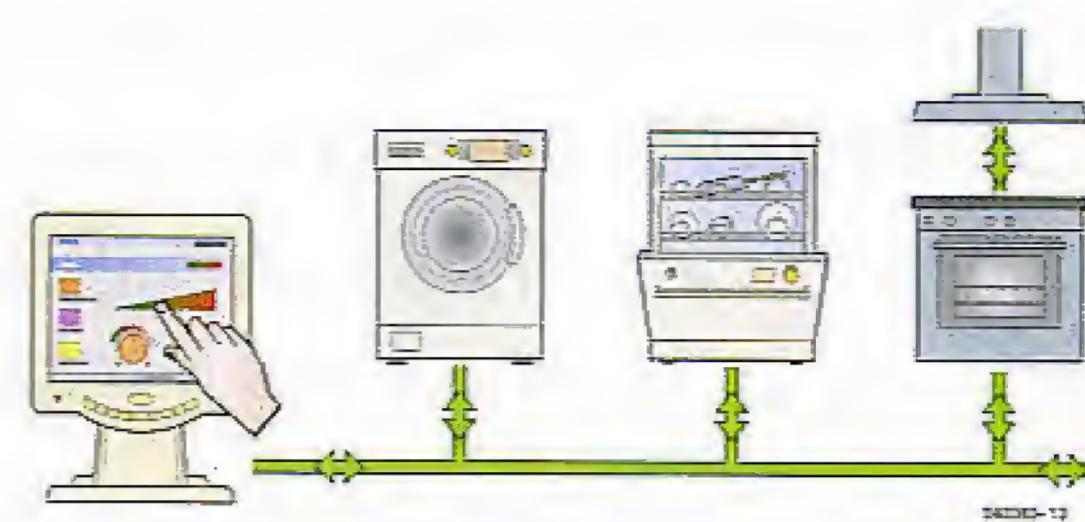


Figure 4.  
Eventually, all  
equipment in the  
home will be able to  
communicate with  
each other.

will be discussed in a future instalment of E-Online. Meanwhile, why not have a look at what's brewing on the websites of 'Homeseer' and 'Home Automated Living', which supply examples of hardware and software that allows you to start integrating and automating your home right here and now. The relevant web links may be found below.

(040363-1)

### Web links

[www.hometoys.com](http://www.hometoys.com)  
[www.smarthomeforum.com](http://www.smarthomeforum.com)

### Software and hardware

[www.homeseer.com](http://www.homeseer.com)  
[www.automatedliving.com](http://www.automatedliving.com)

## Previously on Elektor

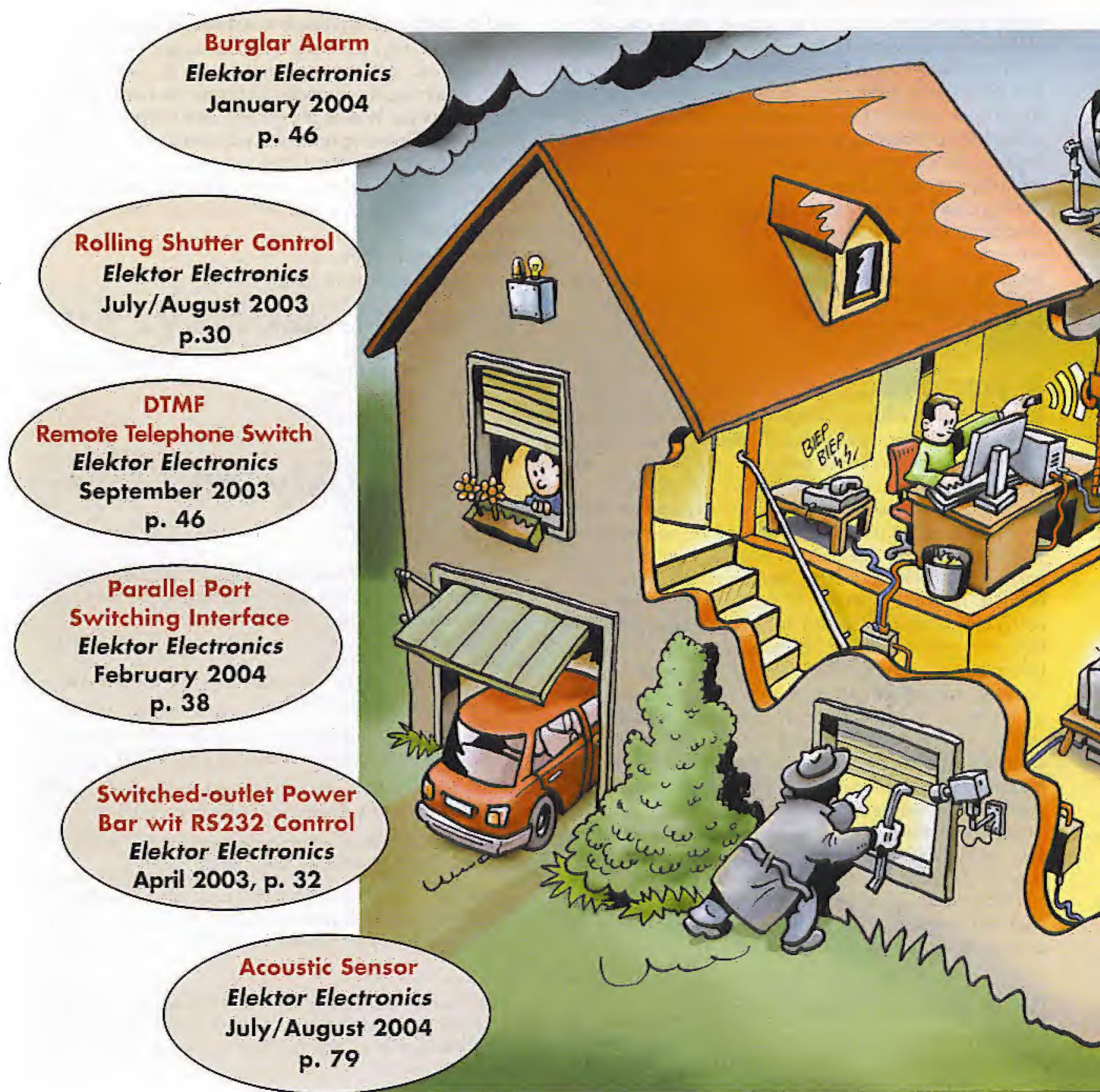
Elektor Electronics has a long history of articles on bus systems suitable for DIY home automation. The most important contributions are listed below.

- RS485 meets CAN; two systems on one bus (Elektor Electronics October 2001)
- RS232 to RS485 Half-Duplex Adapter; advantages of balanced lines (Elektor Electronics May 2002)
- DCI Bus; RS485 home network with a maximum of 64 terminals (Elektor Electronics December 2002)
- USB-RS232 Interface; a compact solution for missing ports (Elektor Electronics April 2003)
- Controller Area Network (CAN bus); intelligent data communications in practice (Elektor Electronics September through December 1999)

Elsewhere in this issue you'll find references to a number of recent construction projects that fit in with this month's focus on Domotics. With a little inventiveness all of these can be bused!

# Back to the

Subscribers and regular readers of Elektor Electronics are accustomed to seeing circuits for use in and around the home. In many cases, these circuits lend themselves to DIY Home Automation. Around the cartoon we've listed a number of interesting projects from past issues.



# future

## Home electronics from the (recent) past

**Wind Speed &  
Direction Meter**  
*Elektor Electronics*  
May 2004, p. 24

**Lightning  
Intensity Detector**  
*Elektor Electronics*  
June 2003, p. 56

**Passive-Optical  
Person Detector**  
*Elektor Electronics*  
February 2003  
p. 22

**Simple  
Sump Pump Control**  
*Elektor Electronics*  
December 2000  
p. 88

**Night Light Control**  
*Elektor Electronics*  
June 2003  
p. 24

**Remote Light  
Control with Dimmer**  
*Elektor Electronics*  
July/August 2003  
p. 18

**iAccess**  
*Elektor Electronics*  
February 2004  
p. 42

**You have Mail!**  
*Elektor Electronics*  
July/August 2004  
p. 57

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Illustration: Peter Willems

(040296)

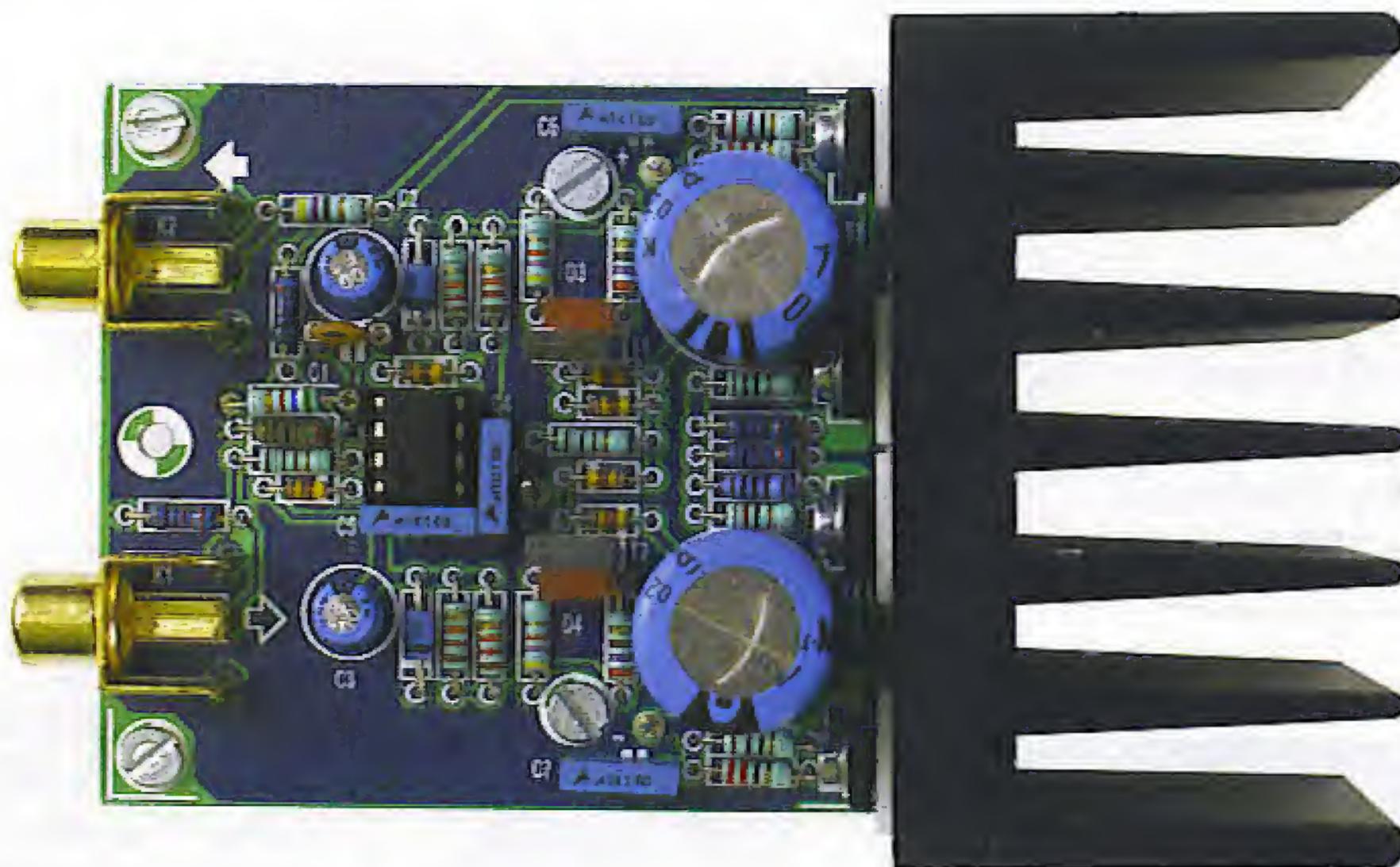


# High Voltage Amplifier

Audio analysers, such as the Audio Precision series have signal generators that for certain test purposes do not have a sufficiently high output voltage. That is why we have designed this 'booster' amplifier stage. It provides the same amount of voltage as a 300-W amplifier into  $8\ \Omega$ . Applications for this amplifier include the testing of measuring filters or an automatic range-switching circuit.

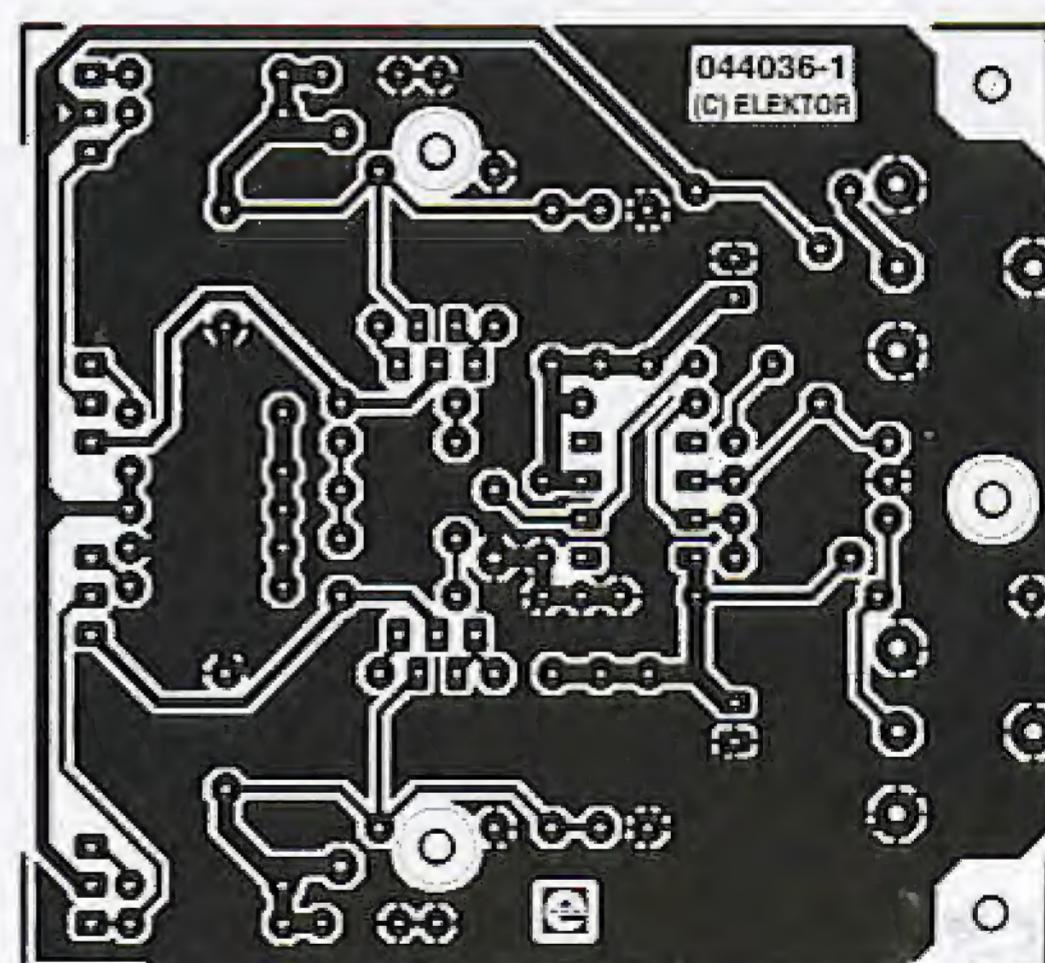
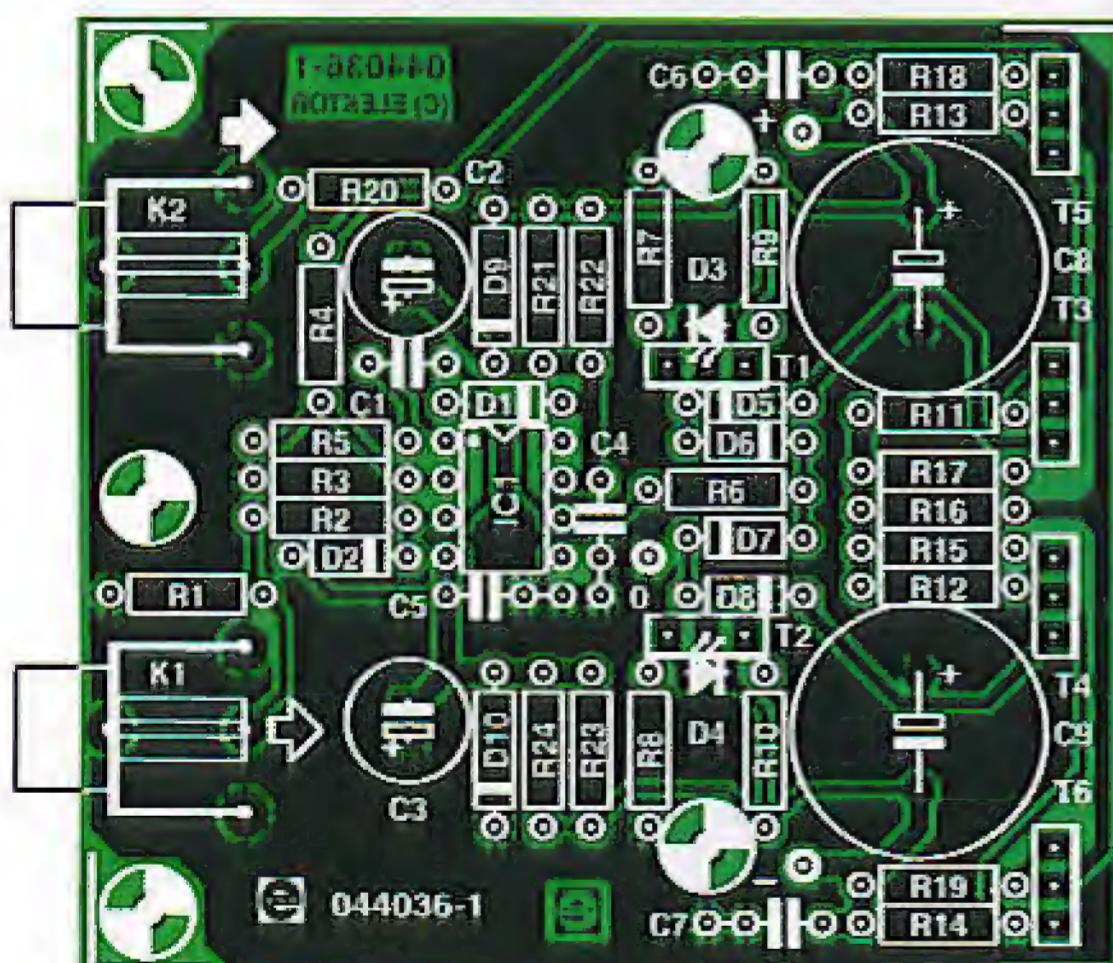
The amplifier can, with a  $\pm 75\text{ V}$  power supply, generate  $50\text{ V}_{\text{RMS}}$ , with an input signal of  $5\text{ V}_{\text{RMS}}$  from the signal generator. In other words, the voltage gain is set to 10 times. In many cases the full bandwidth of the generator is not available at maximum output voltage. For this reason the amplifier gain is a little more than what is actually required for this application.

The graph shows the distortion (THD+N) as a function of output voltage. It is obvi-



ous that at  $1\text{ kHz}$  (curve A), from about  $10\text{ V}$  with  $10\text{ k}\Omega$  load, the limit of the Audio Precision has been reached. The

steps in the curve are caused by range switching in the analyser. At less than  $10\text{ V}$ , the measurement is mostly noise.



## COMPONENTS LIST

### Resistors:

R1,R16,R17 =  $10\text{k}\Omega$   
R2,R6 =  $100\Omega$   
R3 =  $1\text{k}\Omega 10$   
R4 =  $10\text{k}\Omega 0$   
R5 =  $5\text{k}\Omega 6$   
R7,R8 =  $47\text{k}\Omega$   
R9,R10 =  $270\Omega$   
R11,R12 =  $82\Omega$   
R13,R14 =  $220\Omega$

R15 =  $1\text{k}\Omega$   
R18,R19 =  $27\Omega$   
R20 =  $47\Omega$   
R21-R24 =  $12\text{k}\Omega$

### Capacitors:

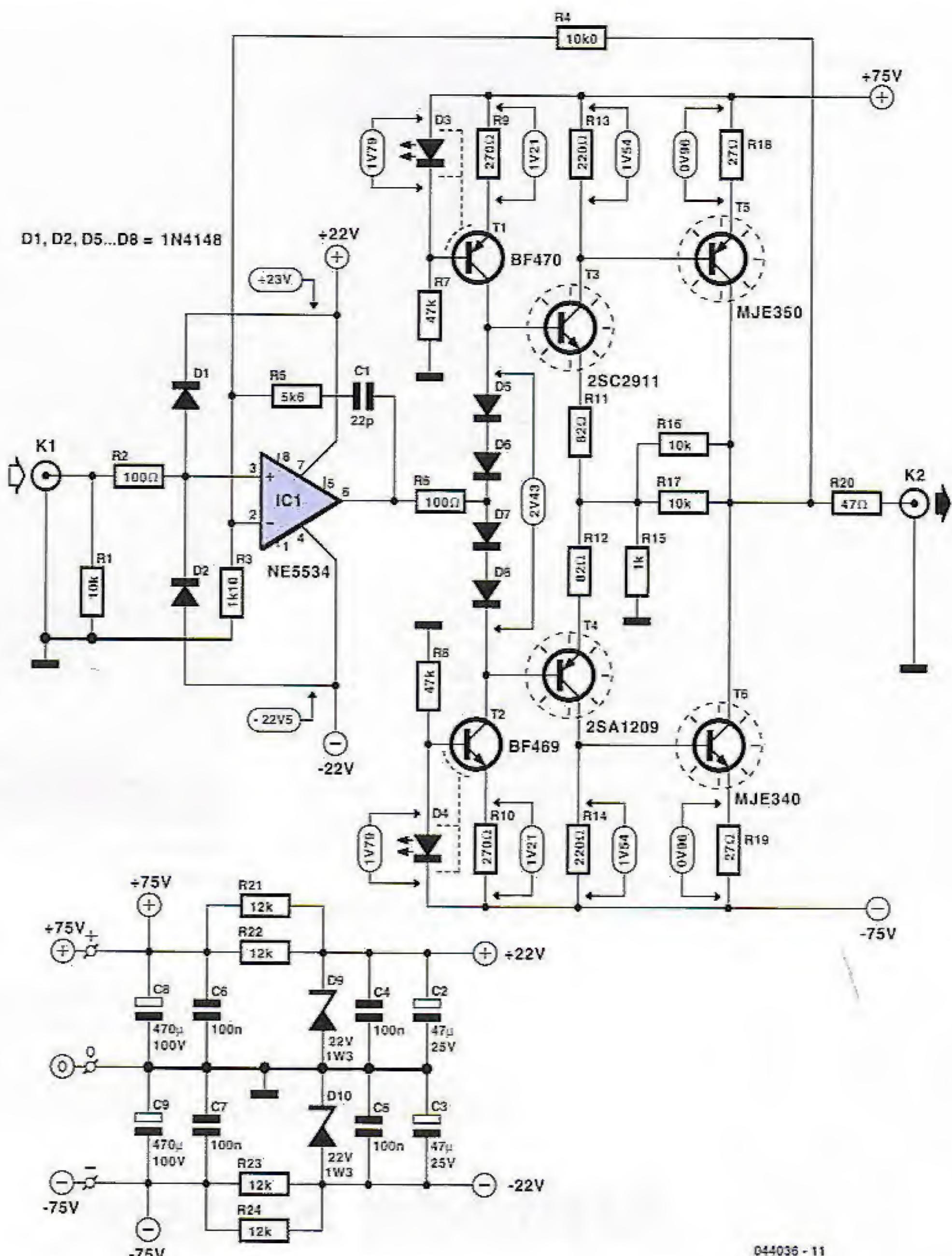
C1 =  $22\text{pF}$   
C2,C3 =  $47\mu\text{F}$  25V radial  
C4-C7 =  $100\text{nF}$  (C6/C7:  $100\text{V}$ )  
C8,C9 =  $470\mu\text{F}$  100V radial

### Semiconductors:

D1,D2,D5-D8 = 1N4148  
D3,D4 = rectangular LED, red  
D9,D10 = zener diode 22V 1.3W

T1 = BF470  
T2 = BF469  
T3 = 2SC2911  
T4 = 2SA1209  
T5 = MJE350  
T6 = MJE340  
IC1 = NE5534

**Miscellaneous:**  
K1,K2 = cinch socket, PCB mount, T-709G from Monacor/Monarch  
Heatsink, 2.5 K/W (e.g. Fischer type SK100, 50mm height)  
PCB, order code 044036-1 from The PCBShop



044036 - 11

From 20 kHz (curve B) the distortion increases slowly, but with only 0.008% at 50 V remains small even at nearly full output! Both curves were measured with a bandwidth of 80 kHz.

The amplifier is built around the old faithful NE5534 and a discrete buffer stage. The buffer stage has been designed as a symmetrical compound stage, which maximises the output voltage. The advantage of the compound stage is that it is possible to have voltage gain. This possibility has been taken advantage of, because the NE5534 can operate from a maximum of only  $\pm 22$  V (and that is pushing it!). We make the assumption that the opamp can supply 15 V<sub>peak</sub> without distortion. There is, therefore, 4.7-times gain required in the compound-stage. This is set with the local negative feedback R15,

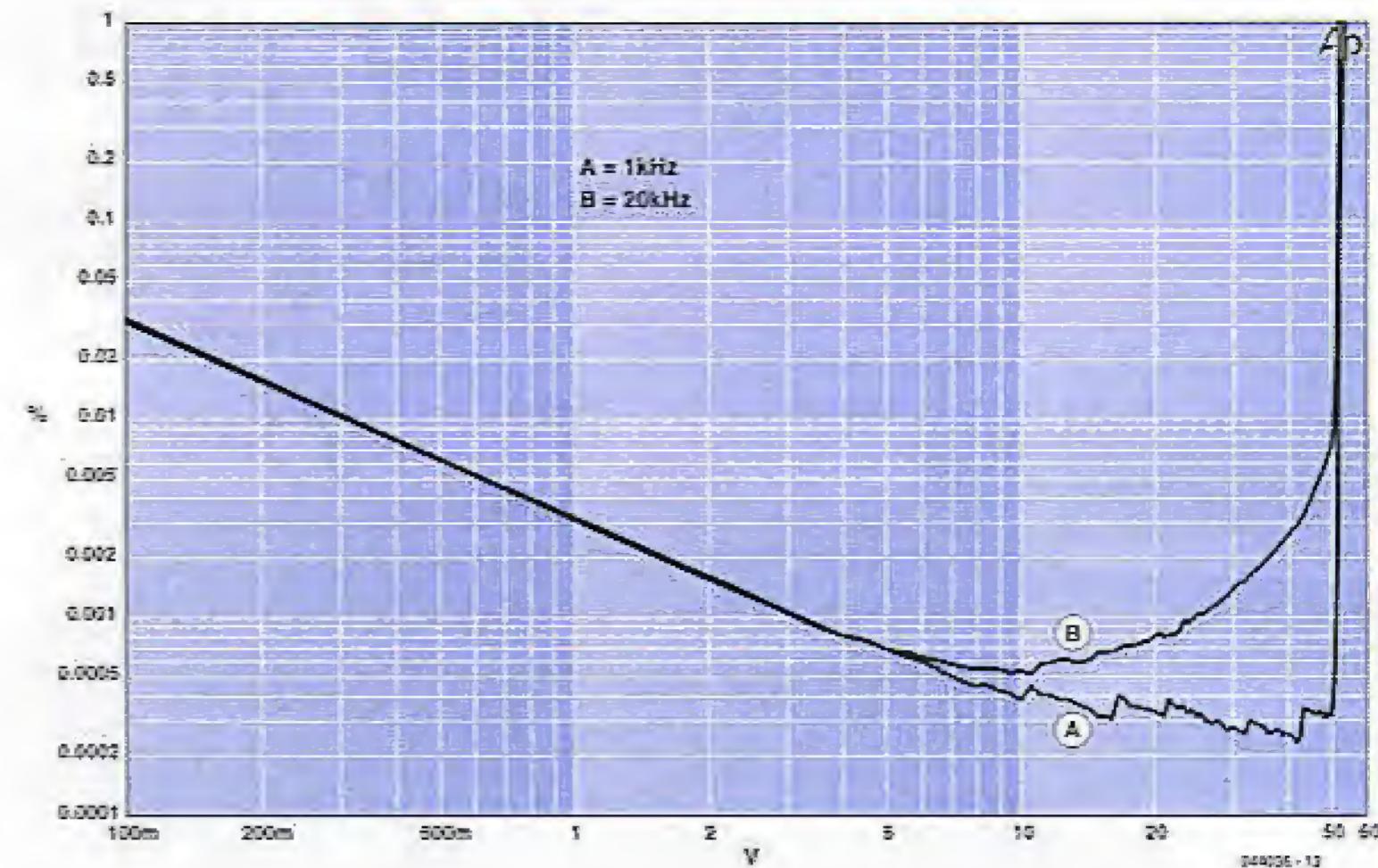
R16 and R17. The values are as small as possible to enable the use of normal resistors. At first glance, the gain should in theory be 6 times, but the stages T3 and T4 influence the local feedback. When driven with DC, the dissipation in R16 (R17) will be a maximum of about 0.3 W. For T5 and T6, the MJE340 and MJE350 were selected. This pair has been practically unrivalled for many years. At a collector/emitter voltage of 150 V, the MJE350 can carry a collector current of 40 mA. The output stage is, with an idle current of 35 mA through T5 and T6, well into class-A operation. Local and total feedback requires a maximum of 20 mA. Despite this 'no load' the output transistors are well within their safe operation area. The minimum load is a few k $\Omega$ . If

necessary, R20 can be increased to 1 k $\Omega$  or a current limit circuit can be added. However, this is likely to reduce the quality of the amplifier.

The drivers T3 and T4 are a couple of new transistors from Sanyo. These have a considerably better linearity ( $h_{FE}$ ) and have a lower capacitance than the MJEs. The maximum collector/emitter voltage is 160 V. At this value (DC), up to 7 mA may be processed (or 20 mA for 1 s). The actual operating voltage for these will in practice be about 100 V. With a current setting of 7 mA, these transistors are operating well inside their safe operating area. These are details that have to be taken into account because of the high power supply voltage.

T3 and T4 are, with the aid of four 1N4148 diodes, biased at a fixed current, so it is not necessary to adjust the

quiescent current. The current through these diodes is set with two symmetrical current sources to a value of about 4.5 mA ( $T_1$  and  $T_2$ ). BF-series devices were selected for this application because they have even lower capacitance. Should the availability of the BF469 and BF470 prove to be a problem then it is possible to substitute the same devices as used for  $T_3$  and  $T_4$ , i.e. 2SC2911 (NPN) and 2SA1209 (PNP) respectively. This stage is driven from the middle of  $D_5$  through  $D_8$ , so that the opamp only needs to deliver the amount of current to compensate for the difference in current between  $T_3$  and  $T_4$ .  $R_6$  protects the output of IC1 from any possible capacitive feedback from the output stage. The overall feedback loop is set with  $R_4$  and  $R_3$ . This has been quite accurately adjusted for a gain of 10 times ( $A = 1 + R_4/R_3$ ), so the actual value is 10.09 times.  $R_5$  and  $C_1$  are the compensation network for the entire amplifier by providing the opamp with local feedback. Note that if you change the gain of the amplifier, the compensation network has to change as well. An NE5534 has internal compensation when the gain is 3 or greater. So the ratio between  $R_5$  and  $R_3$  must be greater than 2.



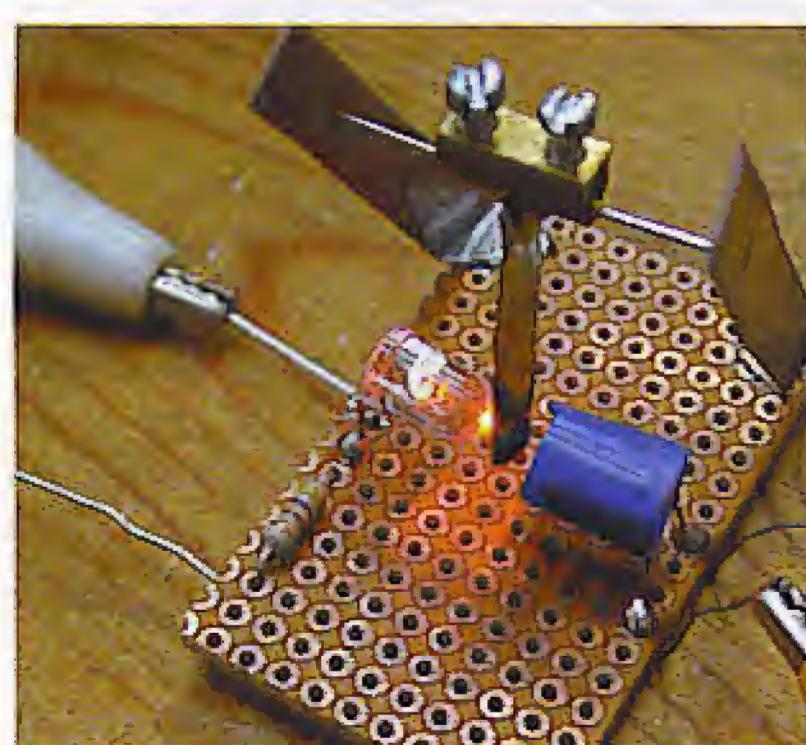
The bandwidth of the amplifier at 11 MHz is quite good (measured at  $40 \text{ V}_{\text{rms}}$ ).  $R_2$ ,  $D_1$  and  $D_2$  provide input protection.  $R_1$  determines the input resistance, which is  $10 \text{ k}\Omega$ . The value of  $R_1$  may be increased, but the result will be a higher output offset. The bias current of IC1 can easily be  $0.5 \mu\text{A}$  and that explains the offset of 50 mV at the output. For most applications this value will not cause any problems.

The power supply for the opamp is

derived from the  $\pm 75\text{-V}$  power supply using two zener diodes. This is designed with two parallel resistors so that it is not necessary to use special power resistors.  $C_6$  through  $C_9$  decouple the output stage and  $C_2$  through  $C_5$  decouple the opamp. The total current draw of the prototype, after it had warmed up, was about 57 mA. The 'High voltage supply' elsewhere in this issue can be used as the power supply.

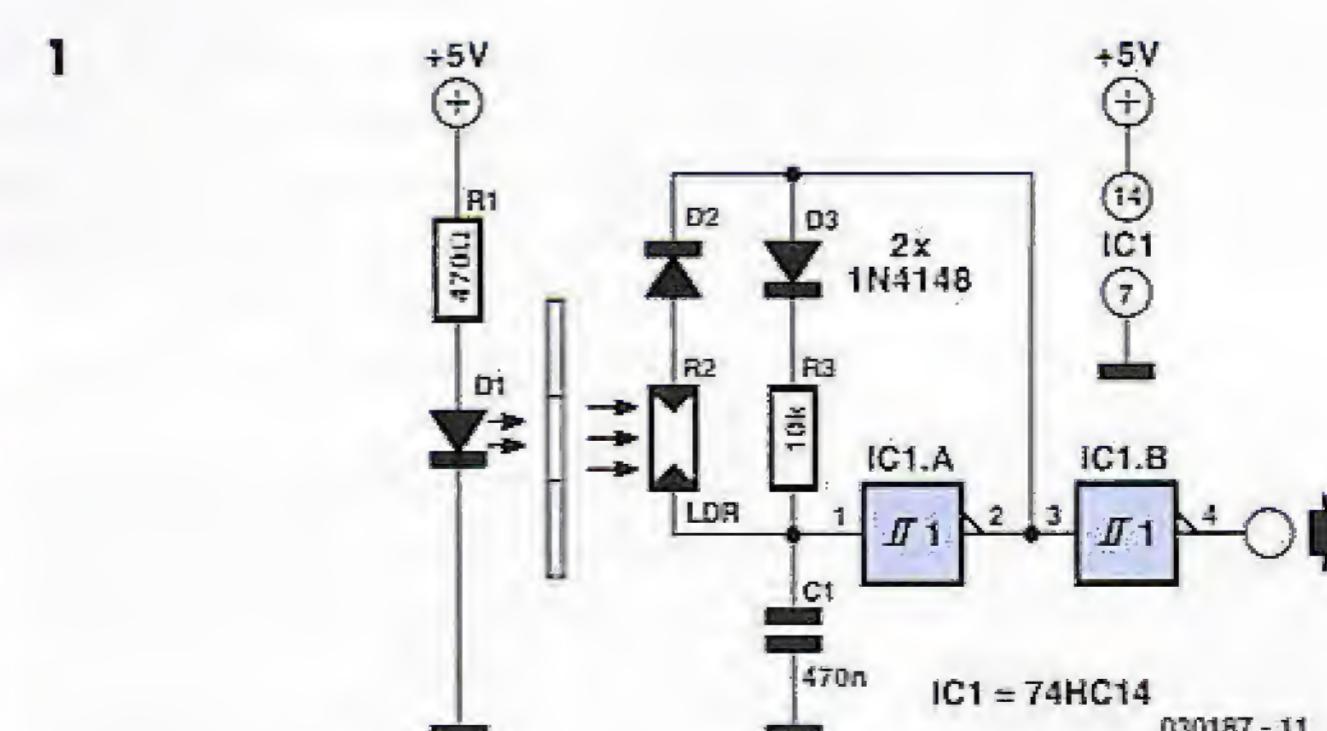
(044036-1)

## Attitude Sensor



Bernd Oehlerking

The circuit presented here (in two versions) uses a light barrier as a position sensor. In the first version (Figure 1), the light barrier consists of an LED (D1) for the light source and a LDR (R2) for

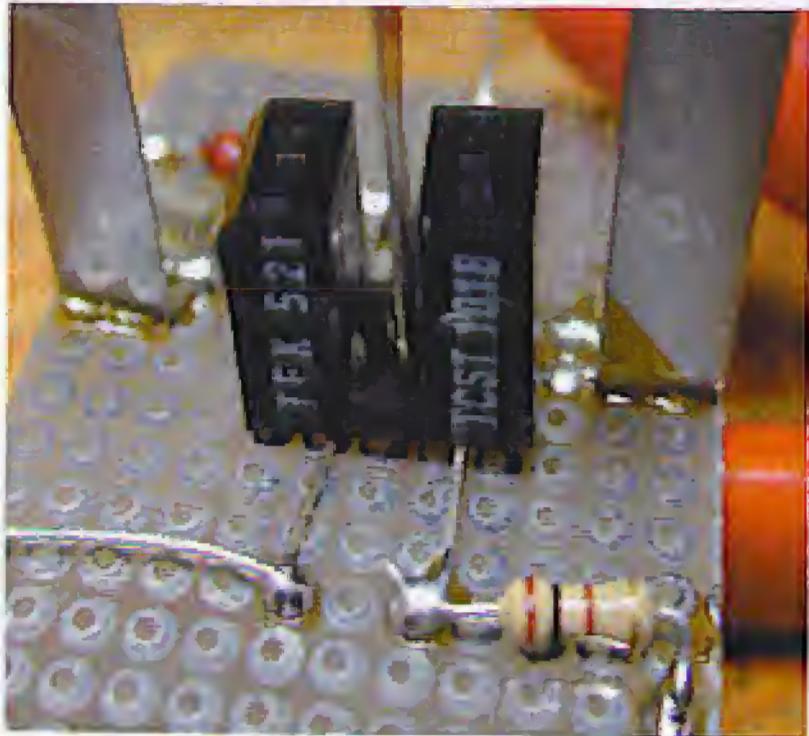


the receiver. The LDR is part of a CMOS oscillator that generates a digital signal (pulse waveform) whose high/low ratio (duty cycle) and frequency depend on the intensity of the impinging light. With the arrangement shown in the photo, the sensor is used together with a posi-

tioner. The light-dependent resistor is more or less obscured by a pendulum, so the duty cycle and frequency of the output signal depend on the position of the actuator. If the LED and pendulum are omitted, the light falling on the light-dependent resistor can also be used to

directly determine the frequency and duty cycle.

The second version (**Figure 2**) represents a refinement of the positioning mechanism. As can be seen in the photo, it differs from the first version by using a slotted light barrier. The pendulum that swings in the slot of the light barrier is formed by two simple strips of tinplate (which can be cut from a tin), which are bound together using a cloth-covered elastic band. A bit of solder applied to the end of the strips provides the pendulum weight.



As in the first version, the light receiver (photodiode) of the slotted light barrier is more or less obscured depending on the position of the positioner. The photodiode in turn drives a pulse generator made from two CMOS Schmitt-trigger inverters, whose duty cycle and frequency are highly variable. A dc voltage that directly indicates the position of the pendulum can be generated from the pulse waveform using a low-pass RC network connected to the output of the generator.

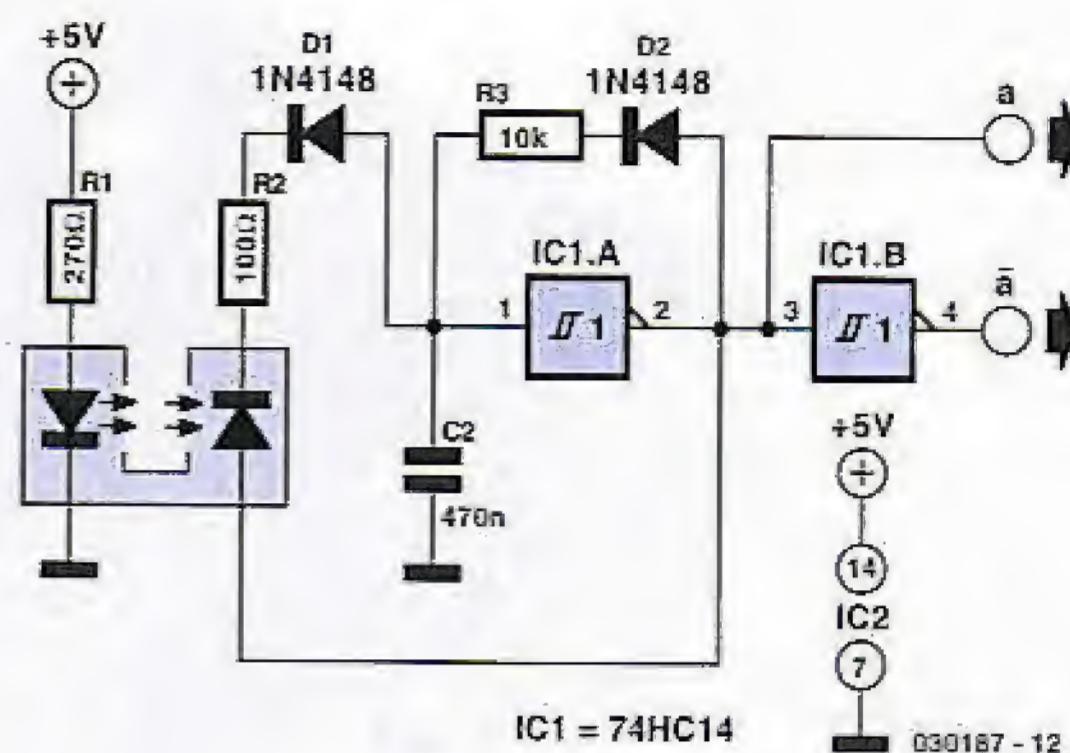
Suitable types of slotted light barriers are

for example the TCST 1018 and TCST 2000 (Conrad).

The idea for this positioner came from working with a multi-rotor helicopter whose motor speeds had to be adjusted if the helicopter threatened to tip over. There are certainly other possible applications (such as a tremor sensor) for this sensor, which is easy to build and adjust and which responds to only a few degrees of tilt with a large change in duty cycle.

(030187-1)

**2**

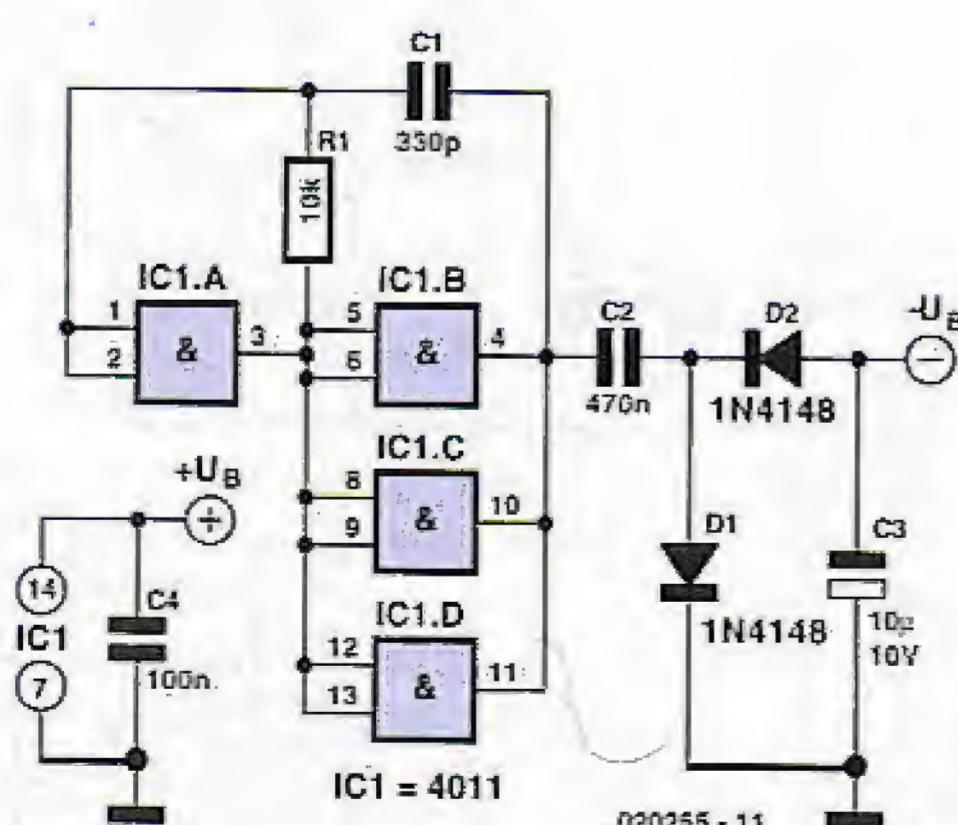


IC1 = 74HC14

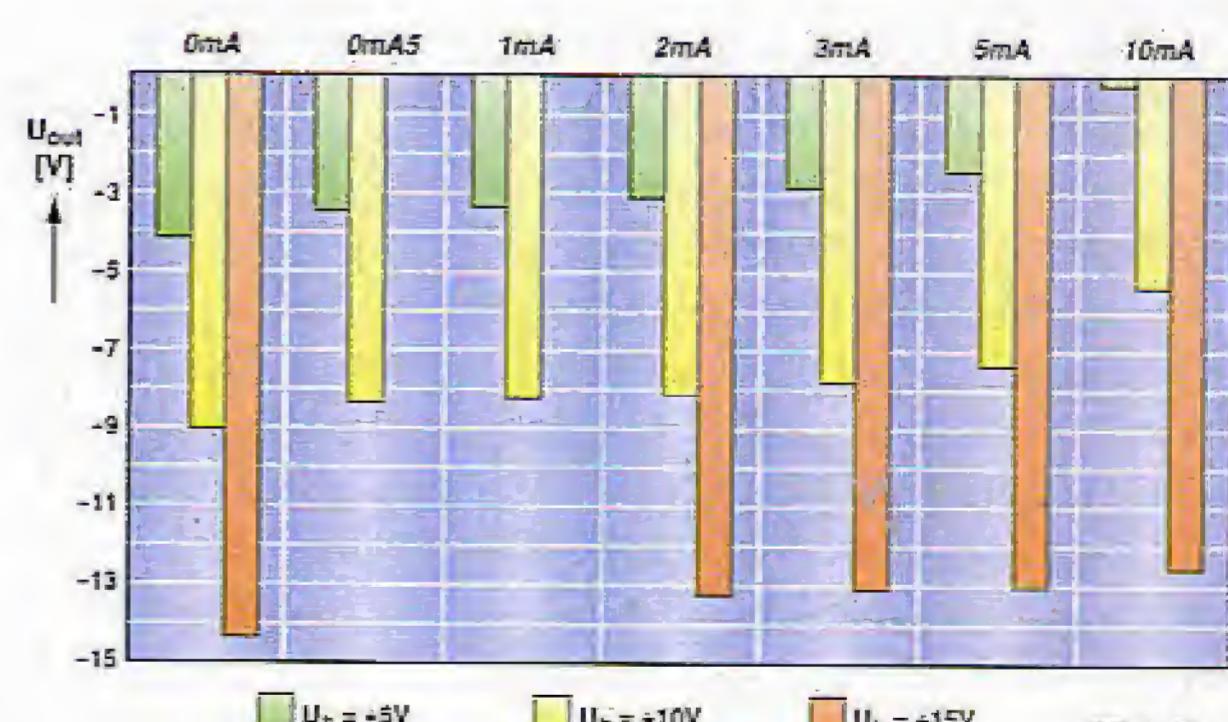
030187 - 12

## Negative Auxiliary Voltage

(000)



020255 - 11



020255 - 12

Ludwig Libertin

Some circuits need a negative supply voltage that only has to supply a small current. Providing a separate transformer winding for this (possibly even with a rectifier and filter capacitor) would be a rather extravagant solution. It can also be done using a few gates and several passive components.

The combination of gate IC1a and the other three gates (wired in parallel) forms a square-wave generator. D1 and D2 convert the ac voltage into a dc voltage.

As a CMOS IC is used here, the load on the negative output is limited to a few milliamperes, depending on the positive supply voltage (see chart), despite the fact that three gates are connected in paral-

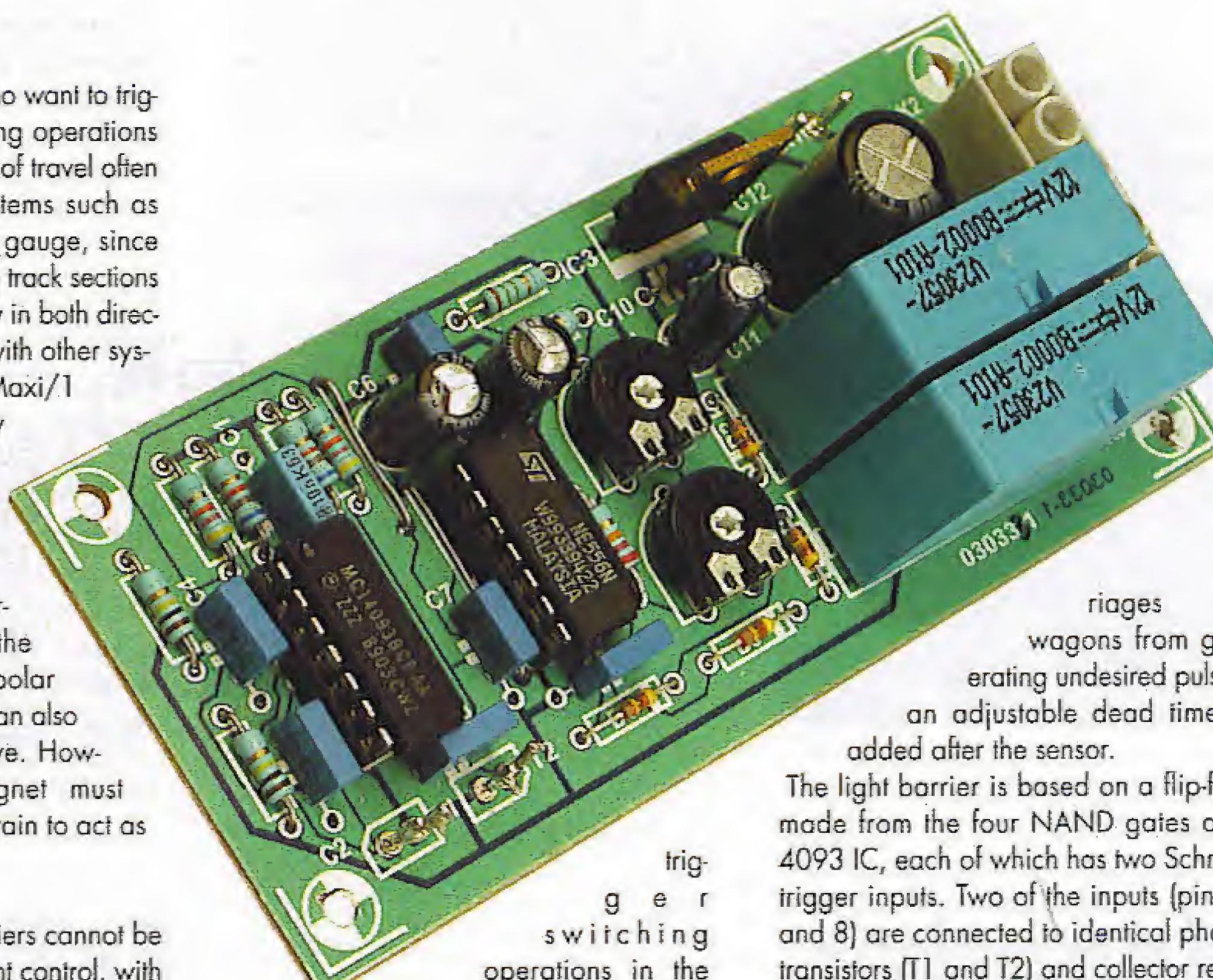
lel. However, as the figure shows, the negative voltage has almost the same magnitude as the positive input voltage, but with the opposite sign. If a clock signal in the range of 10–50 kHz is available, it can be connected to the input of IC1a, and R1 and C1 can then be omitted.

(020255-1)

Robert Edlinger

Model railway hobbyists who want to trigger train-controlled switching operations depending on the direction of travel often have things easy with systems such as Märklin HO or Minicub Z gauge, since the corresponding switching track sections can be actuated individually in both directions. Things are different with other systems, such as the Märklin Maxi/1 gauge. Here it's necessary to use selective switching hardware for this purpose. A popular approach is to use reed switches together with permanent magnets fitted to the bases of the vehicles. Unipolar and bipolar Hall switches can also achieve the same objective. However, a permanent magnet must always be present on the train to act as a trigger element.

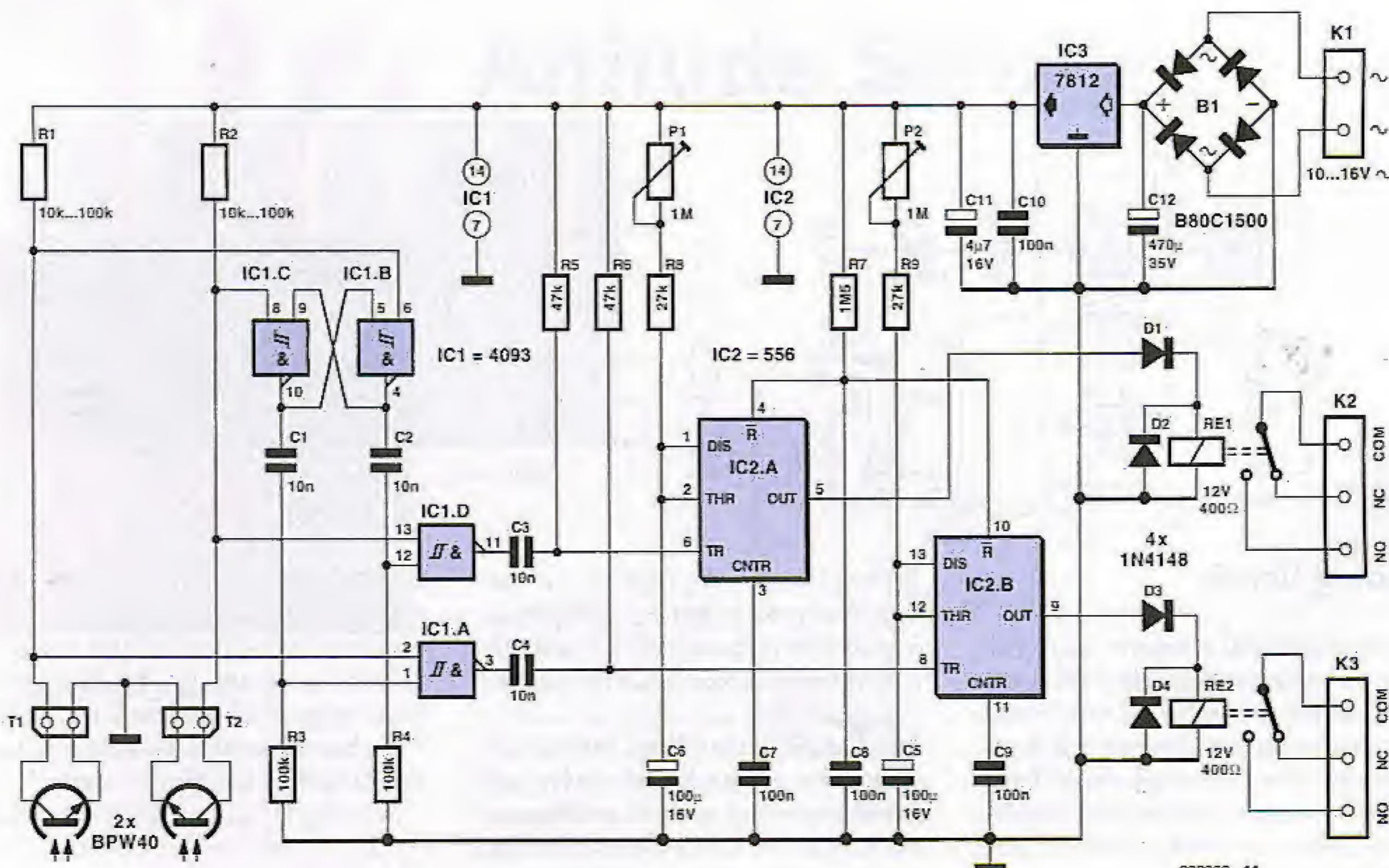
Although normal light barriers cannot be used for direction-dependent control, with a bit of additional effort and expense they can be built such that trains selectively



trig-  
g e n  
switching  
operations in the  
desired direction. To pre-  
vent the gaps between car-

riages or wagons from generating undesired pulses, an adjustable dead time is added after the sensor.

The light barrier is based on a flip-flop made from the four NAND gates of a 4093 IC, each of which has two Schmitt-trigger inputs. Two of the inputs (pins 6 and 8) are connected to identical phototransistors (T1 and T2) and collector resistors, and in the quiescent state when the phototransistors are illuminated and thus



# COMPONENTS LIST

## Resistors:

R1,R2 = 10-100k $\Omega$  (see text)  
 R3,R4 = 100k $\Omega$   
 R5,R6 = 47k $\Omega$   
 R7 = 1M $\Omega$  5  
 R8,R9 = 27k $\Omega$   
 P1,P2 = 1M $\Omega$  preset

## Capacitors:

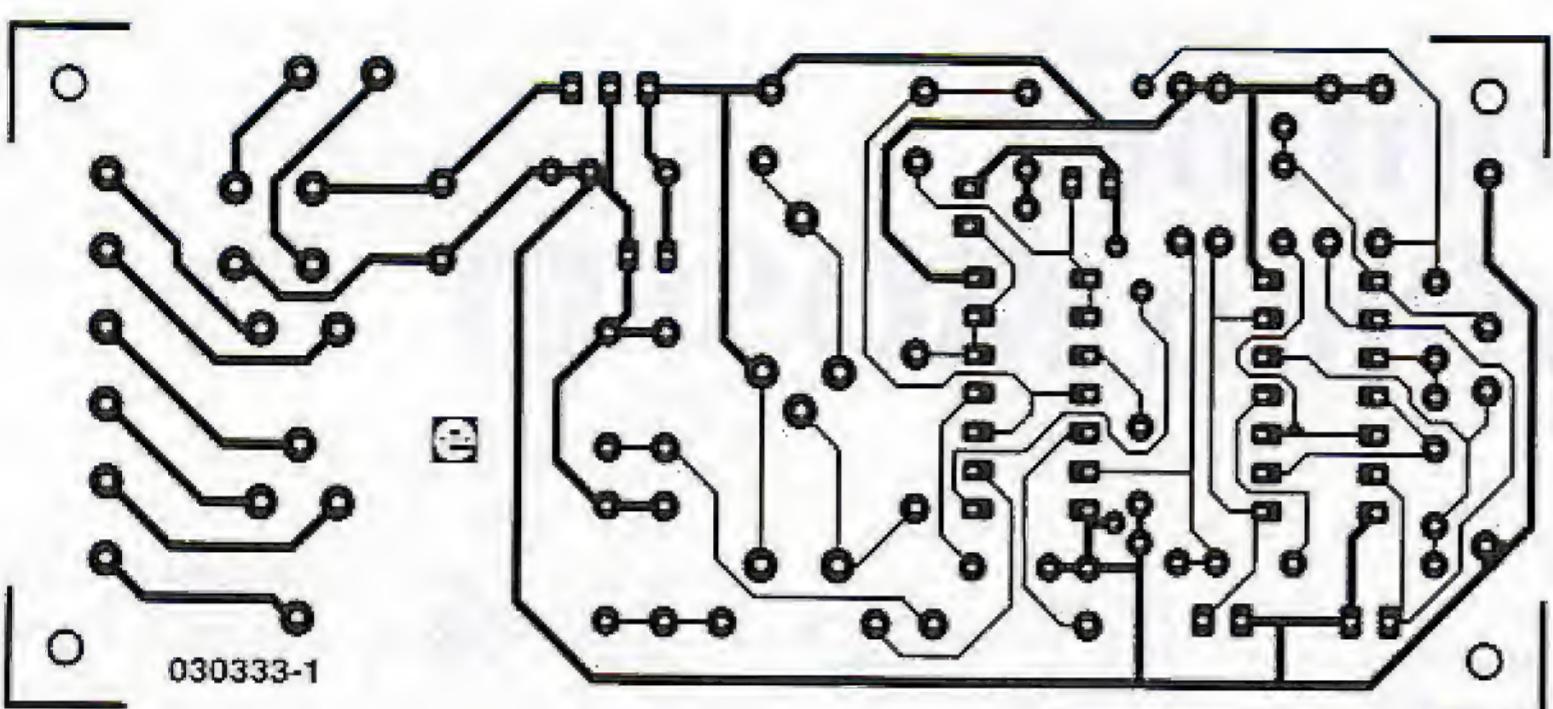
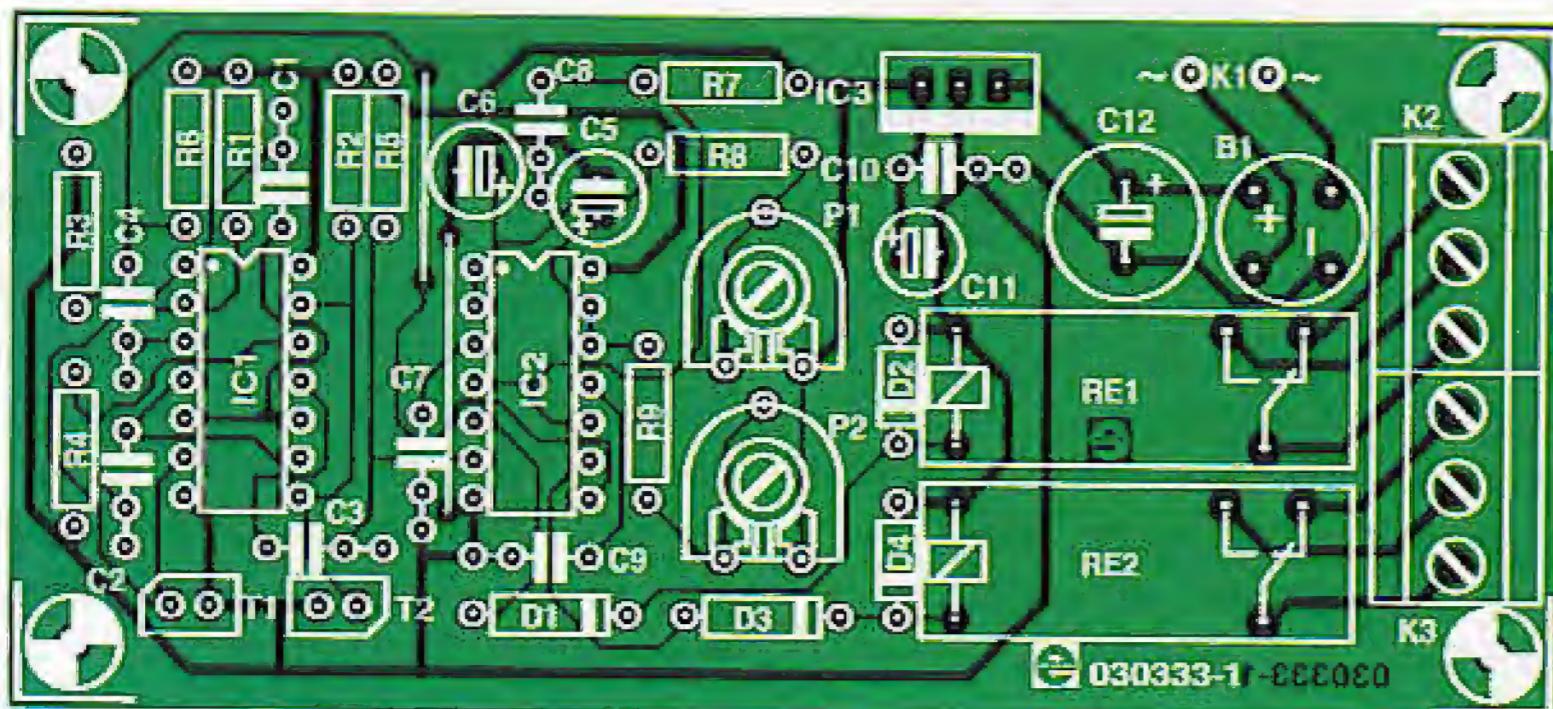
C1-C4 = 10nF  
 C5,C6 = 100 $\mu$ F 16V radial  
 C7-C10 = 100nF  
 C11 = 4 $\mu$ F7 16V  
 C12 = 470 $\mu$ F 35V

## Semiconductors:

B1 = B80C1500 (80V piv, 1.5A)  
 D1-D4 = 1N4148  
 IC1 = 4093  
 IC2 = 556  
 IC3 = 7812  
 T1,T2 = BPW40

## Miscellaneous:

RE1, RE2 = 12V relay (400 $\Omega$ ),  
 1-changeover contact  
 K1 = 2 solder pins  
 K2,K3 = 3-way PCB terminal block, lead  
 pitch 5mm  
 PCB, order code 030333-1 from The  
 PCBShop



conducting, they remain Low. Both gate outputs (pins 4 and 10) are then High. If a vehicle now blocks one of the phototransistors (for example T1, although the circuit naturally works the other way around as well), the signals on the input and output of gate IC1d change levels. The output of gate IC1c is not affected by this, even though its 'internal' input (pin 9) goes low. If the vehicle also blocks T2 as well, nothing changes until it has travelled past T1. When that happens, the pin 4 output goes High again, but the pin 10 output toggles Low. When the vehicle has finally passed both phototransistors, pin 10 also goes back to the High level. The flip-flop is then restored to its original state.

For this behaviour to take occur, phototransistors T1 and T2 must be arranged such that when a vehicle passes by, at first only one of them is blocked, then both, and finally only the other one. This means that the distance between the phototransistors must always be less than the length of the vehicle.

When an output level changes, a pulse with a duration of around 10 ms appears at the input of gate IC1b (pin 12) or IC1a (pin 1). The time constants are determined by the timing networks (R3/C1 and R4/C2). As a High level (generated by the obscured phototransistor) is required

on the other gate input (pin 13 or 2) to allow the pulse to pass through the gate, only one of these two pulses can proceed further to act as a trigger signal for the subsequent timer stage.

The two identically configured timers of the 556 dual timer IC function as monostable multivibrators, and thus act as pulse stretchers. Each of them drives an output relay with switch-over contacts. The time constants of the monostables can be varied over the range of 3–170 s using the adjustment networks P1/R8/C6 and P2/R9/C5, independent of the supply voltage. RC network R7/C8 ensures that the two timers are in the quiescent state (outputs Low) after power is switched on. Freewheeling diodes D2 and D4 are essential with inductive loads; they bypass the counter-EMFs generated by the relay coils. D1 and D3 keep the voltage across the freewheeling diodes away from the timer outputs. If you want to have a visual operation indicator, D1 and D3 can be replaced by red LEDs with a voltage drop of 1.6–2.0 V. As the circuit dissipates a fair amount of power, a small heat sink is recommended for the fixed voltage regulator (IC3), to keep it from overheating. We have designed a circuit board layout for this circuit, which can be fitted with components fairly quickly. Don't overlook the (single) wire bridge between C6 and

R5, and ensure that the electrolytic capacitors, diodes, transistors and ICs are fitted the right way around. The ICs can be fitted in sockets if you wish.

As the circuit board is relatively large, it probably should be mounted 'under the floor'. In that case, the phototransistors will have to be fitted off the board. The leads from the phototransistors to the circuit board should be screened and certainly not be longer than around 10 cm.

The values of the two collector resistors (R1 and R2) for phototransistors T1 and T2 can be varied over a wide range (10 k $\Omega$  to 100 k $\Omega$ ) in order to match the sensitivity to specific conditions. However, increasing the resistance not only increases the response sensitivity and thus the range, it also increases the susceptibility to interference from stray light (which is anyhow rather high). If you have to deal with bright stray light (direct sunlight or fluorescent lamps in the immediate vicinity), you should fit the transistors with lengths of small-diameter plastic tubing blackened on the inside and/or IR filters with maximum sensitivity in the invisible spectral range of 800–900 nm.

Small incandescent lamps (16 V, 1 W), which naturally also emit IR light, are suitable as light sources. If a visible light source is undesirable, the lamps can be

almost completely 'camouflaged' using infrared filters. The other option is to invest in IR diodes: high-power types such as the SFH485 (100 mA max, 950 nm) allow barrier widths of more than 10 cm without any lenses. With suitable reflectors (with or without lenses), the range can be significantly increased. A value of  $180 \Omega / 1 \text{ W}$  is recommended for the series resistor.

This bidirectional light barrier is suitable for a variety of tasks. For instance, one

relay output can serve as a layover switch in one direction, while a train travelling in the other direction can cause a turnout or points to be actuated. A voice recorder prepared with whistle or bell signals can also be triggered by one of the relays. Flashing warning lights can also be driven, or the relays can act as an automated 'signalman' for barrier gates. Naturally, this light barrier circuit can also be used for all sorts of counting tasks or as an alarm generator in domestic situations, if the nature of the object to be detected makes this possible. If only relatively short pulses (on the order of a tenth of a second) are needed, for instance to drive a counter, the RC networks that determine the timer values must be correspondingly modified. Photoresistors in miniature packages can be placed so close together that entomologists could even use the circuit to count exactly how many bees or bumblebees fly in or out.

(030332-1)

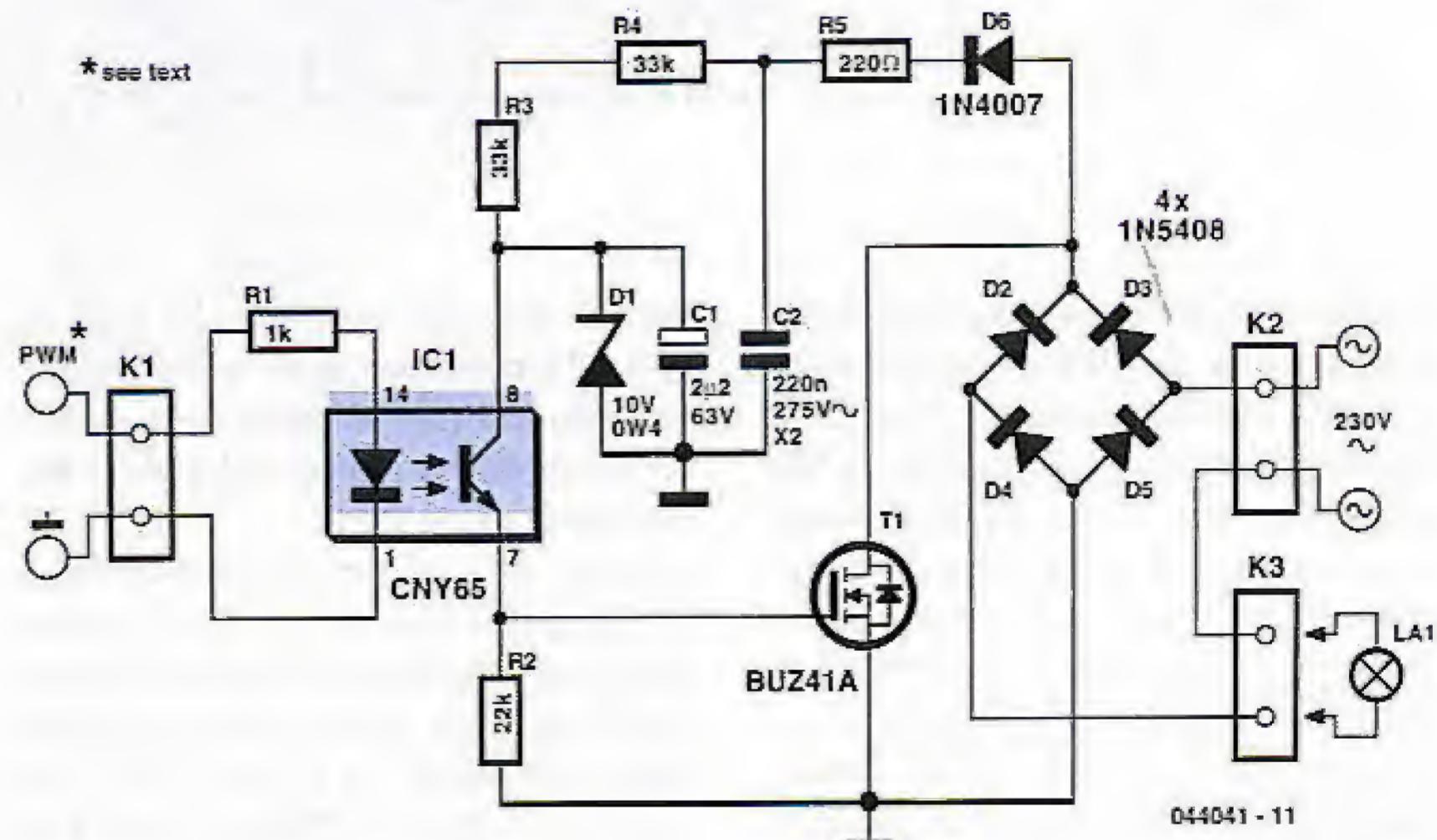
# 005

## Dimmer with a MOSFET

Ton Giesberts

This circuit shows that dimmers intended for use at mains voltage do not always have to contain a triac. Here, a MOSFET (BUZ41A, 500 V/4.5A) in a diode bridge is used to control the voltage across an incandescent bulb with pulse-width modulation (PWM). A useful PWM controller can be found elsewhere in this issue. The power supply voltage for driving the gate is supplied by the voltage across the MOSFET. D6, R5 and C2 form a rectifier. R5 limits the current pulses through D6 to about 1.5 A (as a consequence it is no longer a pure peak rectifier). The voltage across C2 is regulated to a maximum value of 10 V by R3, R4, C1 and D1.

An optocoupler and resistor (R2) are used for driving the gate. R1 is intended as protection for the LED in the optocoupler. R1 also functions as a normal current limiting device so that a 'hard' voltage can be applied safely. The optocoupler is an old acquaintance, the CNY65, which provides class-II isolation. This ensures the safety of the regulator. The transistor in the optocoupler is connected to the positive power supply so that T1 can be brought into conduction as quickly as possible. In order to reduce switching spikes as a consequence of parasitic inductance, the value of R2 has been selected to be not too low: 22 k $\Omega$  is a compromise between inductive voltages and switching loss when going into and out of conduction. An additional effect is that T1 will conduct a little longer than what may be expected



# Discrete Robot

006

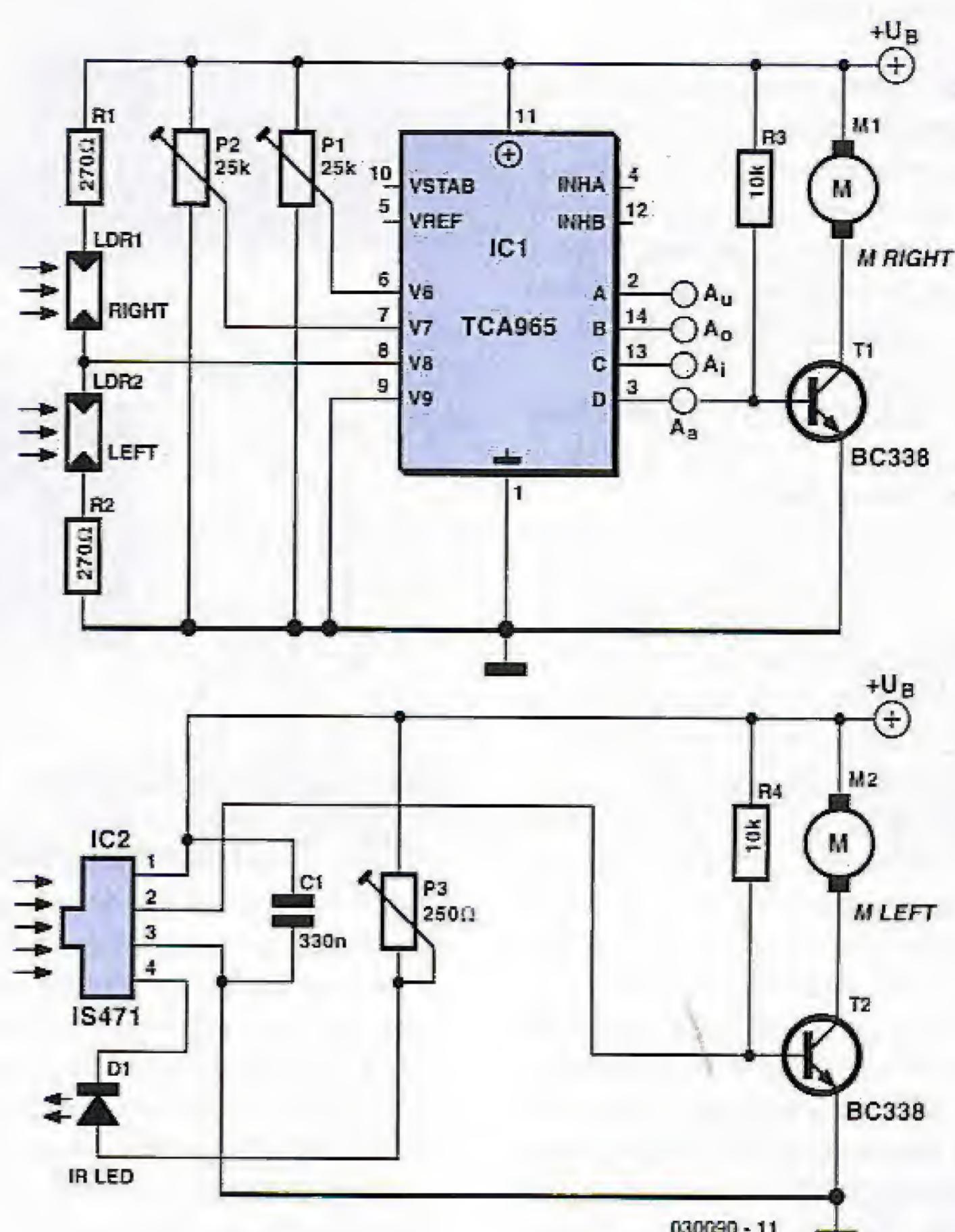
Gerhard Nöcker

This simple robot, which responds to light and avoids obstacles, can be built without using a microcontroller, programmer or PC. The only 'special' component in the circuit is a window discriminator (a fancy version of a window comparator).

Resistors R1 and R2 in combination with light-dependent resistors LDR1 and LDR2 form a voltage divider (with the current being limited by R1 and R2 for bright light). Window discriminator TCA965 compares the mid-point voltage with an upper threshold value (adjustable using P1) and a lower threshold value (adjustable using P2). Outputs AU, AI, AO, and AA go High if the voltage lies below, inside, above or outside this window, respectively; otherwise they remain Low. Output AA switches transistor T1, which drives the right-hand motor. The light-dependent resistors can be attached on the left and right sides of the vehicle, or at the front and rear. This causes the robot to turn to the right, due to the motor on one side being stopped, until the desired lighting relationship is restored. The vehicle will then continue to travel in a straight line until the lighting relationship again changes, at which point it will again turn, and so on.

You can experiment with various behaviour patterns by using the other outputs of the window discriminator. If a transistor is provided for each of the AU and AO outputs of the TCA965, the robot can be made to travel toward or away from a light source, depending on the connections. Using the window discriminator, the robot will operate under the rules of a three-point controller (left, straight ahead, or right). If you fit the light-dependent resistors in a box under the vehicle together with a light source, you can try to have the robot follow a black line on a white background.

A reflective IR sensor enables the robot to respond to obstacles. This is not as simple as it might seem, since the Sharp IS471 operates the IR LED with pulsed light and uses sophisticated detection processing. When an obstacle is detected, the output (pin 2) goes Low and blocks transistor T2. This causes the



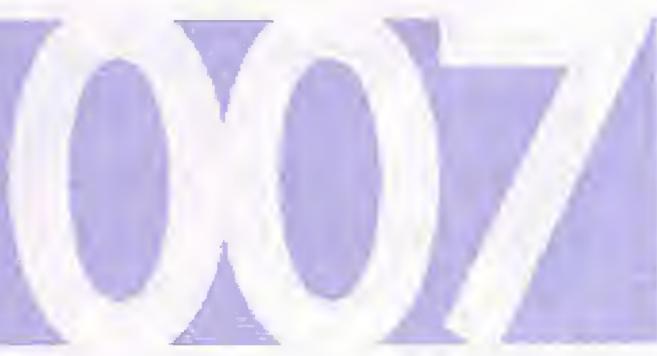
motor to stop, and the vehicle will rotate about the stationary wheel until the obstacle is no longer in its path. The sensitivity of the IS471 can be set using P3. As its range is only around 10–15 cm, the vehicle must not travel too quickly, since otherwise it will not be able to avoid obstacles in time.

This part of the circuit is also open for experimentation. If a relatively large and fast robot requires an obstacle detector (or isn't fitted with the IS471), an ultrasonic detector can also be used. Suitable complete construction kits are available from Conrad, for example. You can also fit a suitable mechanical pushbutton switch mounted on a flexible rod. The obstacle detector can also drive a warning buzzer or a lamp; the circuit leaves lots of room for your own ideas.

The circuit works over a wide range of supply voltages from 4.5 to 16 V. If larger motors are used, transistors with increased power-handling capacity and heavier batteries are necessary. The author connected two 4.8-V rechargeable batteries in series and used BC388 transis-

tors as drivers for Lego micromotors. You can build the robot entirely according to what you have in your parts box. The mechanical elements can also be freely selected, but they partially determine the behaviour and operation of the robot. The author's robot is made from a Lego chassis with a prototyping board holding the circuitry attached using elastic bands. The motors are fitted on the left-hand and right-hand sides. The third wheel at the front can turn freely.

One problem must be mentioned: if an obstacle is detected while an incorrect lighting relationship is present, the vehicle remains standing. In this case, a bit of logic could be added to cause both motors to rotate in reverse. However, that would require directional switches for the motors or motor driver ICs (L293D). The simple circuit would become more complicated and larger, and at some point you would end up using a microcontroller after all — but that's just the point of the story.



# Car Central-Locking System

Christian Vossen

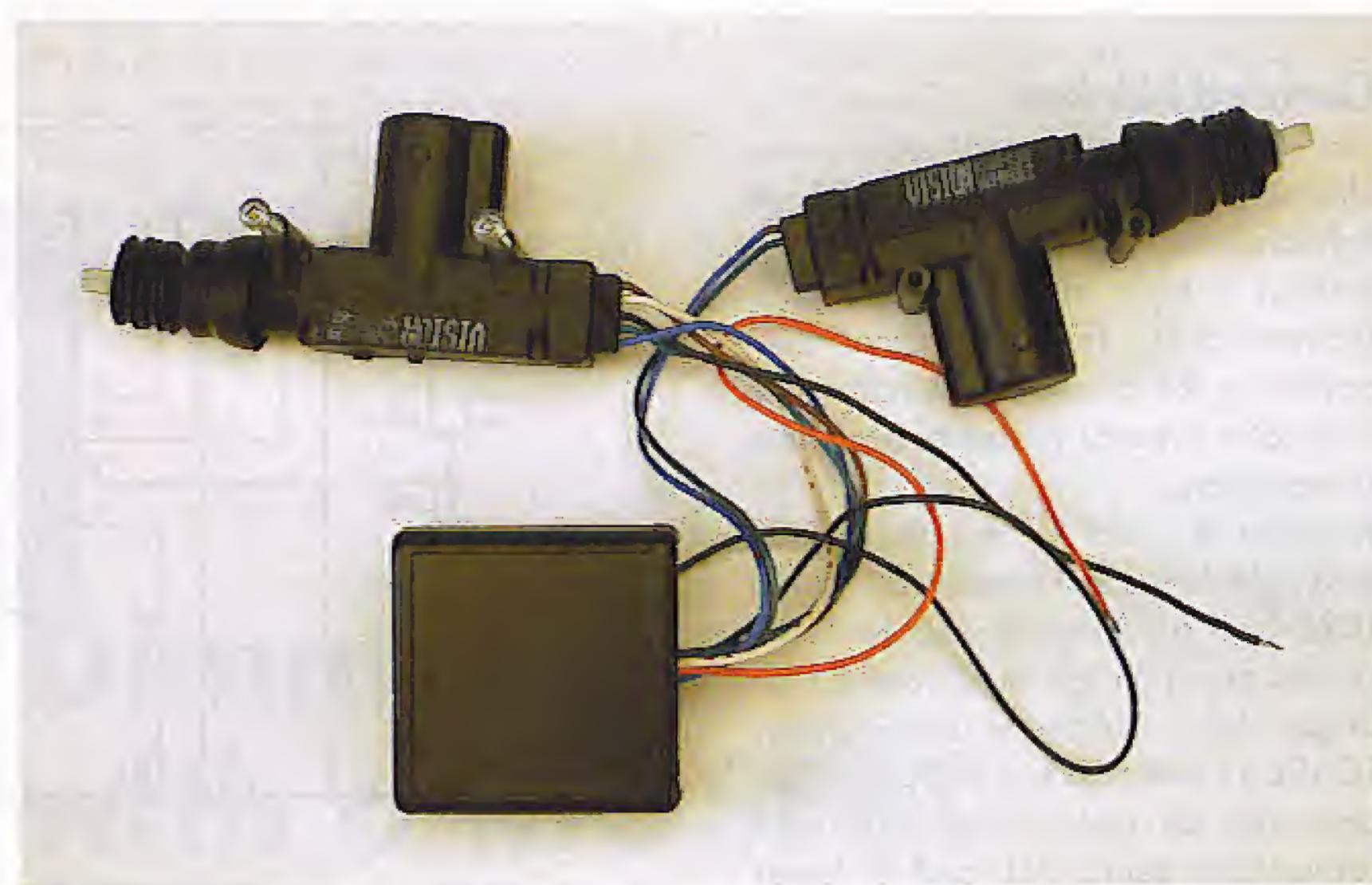
For a few pounds you can buy a kit from any automotive accessory shop that will allow your car to be fitted with a central-locking door system. Such a kit essentially comprises a number of motors. There is also a control unit that enables the whole system to function. Here we show an example of such a unit.

There are 5-wire motors and 2-wire motors. The 5-wire version is used in doors that have a key-lock.

There are 2 connections for the motor itself and 3 connections for the sensor part (an 'open' and a 'close' contact). These sensors determine whether the door is to be unlocked or locked. If there is no key lock in the door, these sensors are superfluous and a 2-wire motor can be used.

The polarity of the motor determines whether the locking mechanism goes up or down. By making a circuit that simply reverses the polarity of the motor, the door can be either locked or unlocked.

The winding of the motor is connected between M1 and M2 in the schematic. When relay Re1 is energised, all motors will, for example, rotate anti-clockwise. By activating Re2 the motors will rotate clockwise. This depends on the actual



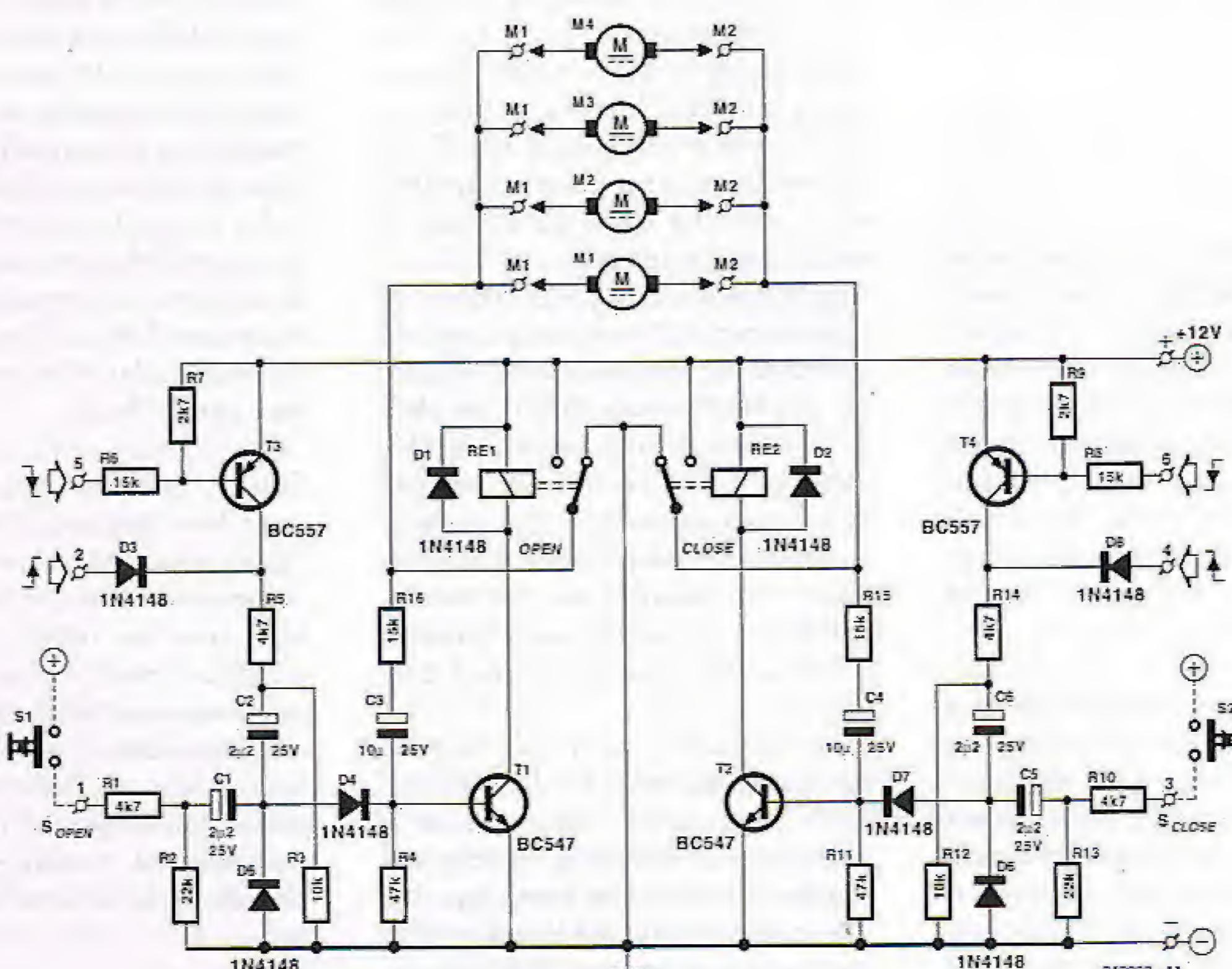
polarity of the motor, of course.

The sensors are connected to R1 and R10. Here you have to pay careful attention. If Re1 causes the door to unlock, then Re1 has must obviously be connected to the 'open' contact. In that case, Re2 is for locking the doors and R10 is then connected to the 'close' contact. The R/C-combinations R16/C3 and R15/C4 ensure that the relays are energised for a certain amount of time (obviously this can be changed if this time is

too short or too long for your doors). This time has to be just long enough to lock or unlock the doors. The third wire of the sensors is the common and has to be connected to +12 V.

The RC circuits at the inputs S<sub>open</sub> en S<sub>close</sub> ensure that the motors are driven only once when the door is locked or unlocked.

In addition, there is a provision to allow the unit to be connected to a car alarm. There are two types of alarm available,



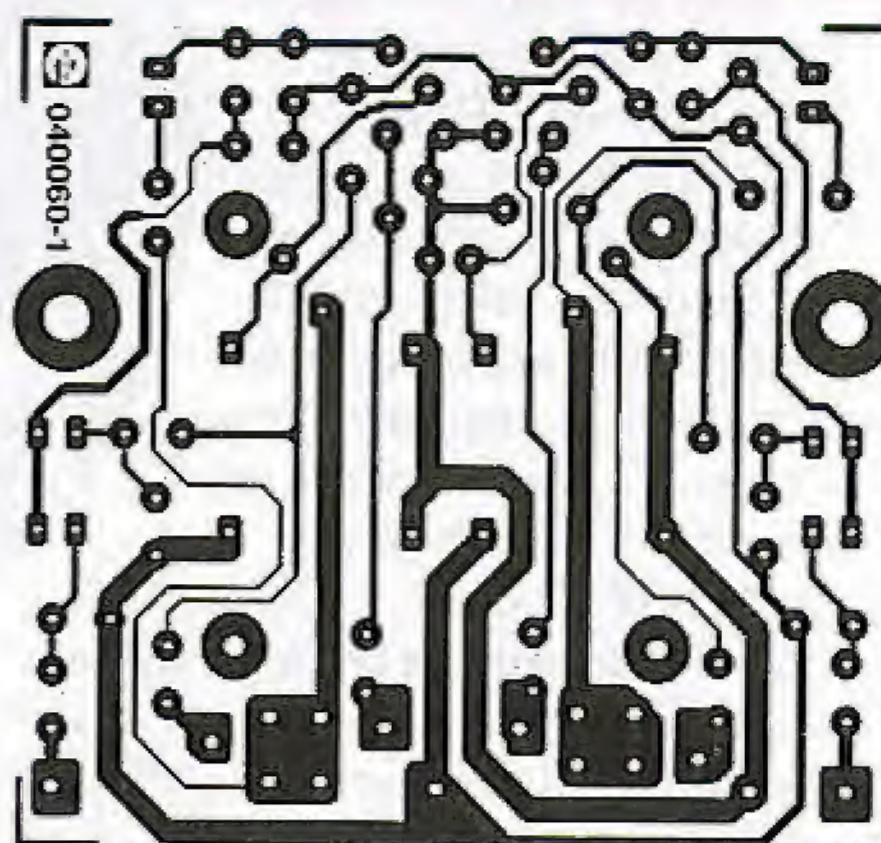
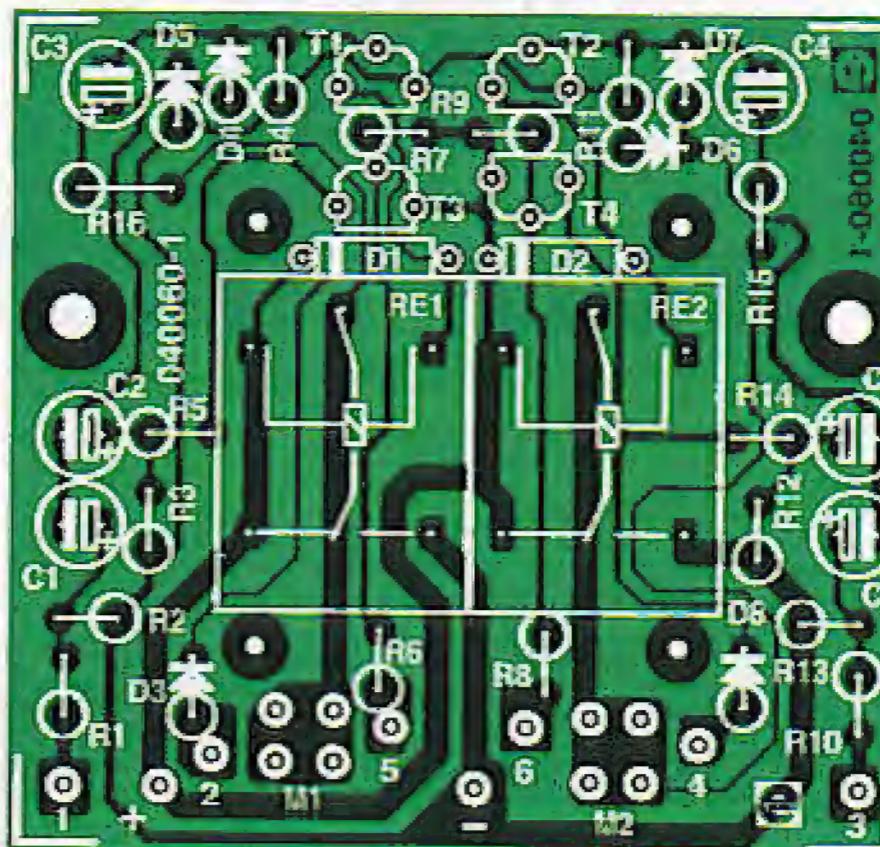
with positive or negative control. In order to make the unit universally applicable, both types of alarm can be used. The circuit around T3 and T4 makes this possible. The diode inputs (D3 and D8) react to a rising edge, R6 and R8 react to a falling edge. An RC time constant is used here as well to ensure that both relays are energised only once.

Maybe this is stating the obvious: a motor unit has to be built into each door. All motor wires and sensor wires are connected in parallel to the electronics.

The actual type of relay is not critical. The type indicated has the following properties: coil 12 V/400 Ω; max. switching current 12 A (AC), max. switching power 1200 VA.

Finally, a car is a hostile environment for electronics. Ensure good connections, use automotive connectors and crimp these on the wires using the appropriate crimping tool. Solder connections in wires are best avoided. They have the tendency to break where the wire transitions into the solder connection when the wire is subject to vibration. Fasten the wires at regular intervals.

(040060-1)



## COMPONENTS LIST

### Resistors:

R1,R5,R10,R14 = 4kΩ

R2,R13 = 22kΩ

R3,R12 = 10kΩ

R4,R11 = 47kΩ

R6,R8,R15,R16 = 15kΩ

R7,R9 = 2kΩ

### Capacitors:

C1,C2,C5,C6 = 2μF 25V radial

C3,C4 = 10μF 25V radial

### Semiconductors:

D1-D8 = 1N4148

T1,T2 = BC547B

T3,T4 = BC557B

### Miscellaneous:

RE1,RE2 = PCB mount relay, 12 V, 1 x changeover, size 19x15.5x15.5 mm (e.g. Conrad Electronics # 504289)

PCB, order code 040060-1 from The PCBShop

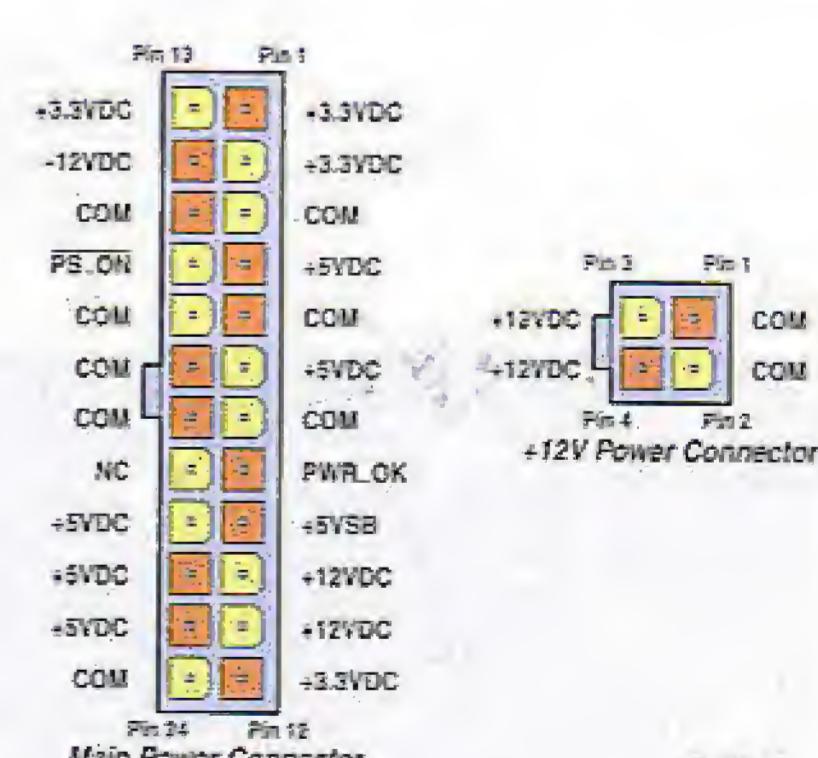
# BTX

## Karel Walraven

What did you say BTX was again? Well, it's just the successor of ATX! ATX is the collective term for the electrical and mechanical characteristics of the present generation of motherboards in your PC. There is now a new standard in its place, BTX (Balanced Technology eXtended Form Factor), with the main advantages of more compact dimensions and better heat removal. When grouping the components on the PCB, careful attention is paid to power dissipation and the possibility of efficiently removing the heat. This is necessary because the CPU meanwhile needs to dissipate 100 W and a respectable video card can easily dissipate 50 W. That is why there has to be serious consideration of how the heat can be removed from the case, where wide cables and other obsta-

cles are no longer allowed to be in the way (also refer to SATA elsewhere in this issue). That the energy consumption is continually increasing can be deduced from the ever more powerful PSU units. While 10 years ago a 150-W power supply was quite adequate, these days 350 or 400 W is the norm. With the BTX standard, there is the assumption of a fan for the power supply (just as before), but also a separate second cooling circuit for the motherboard, drawing in cold air from outside the case and blowing out warm air via a separate path, completely independent of the fan in the power supply.

BTX power supplies will also be able to supply more power. There is a new standard for the power supply connector that increases the number of pins from the current 20 to 24 ('Main power connector'). The first 20 pins keep the same functional-



ity as with ATX motherboards (only -5 V has been omitted!). The extra 4 pins are for more 3.3-V, 5-V and 12-V connections (refer figure). In addition, there has to be a separate 4-way connector ('+12 V power connector') that's intended to power the CPU only.

(040065-1)

Paul Goossens

Sometimes we would like to hide certain equipment to prevent cluttering up our living room or any interior in general. A number of devices lend themselves to be built into a wall adapter. Think of a remote-control extender, for example. All these devices need a power supply and we would prefer to use the mains so that no external connections are required for the power supply.

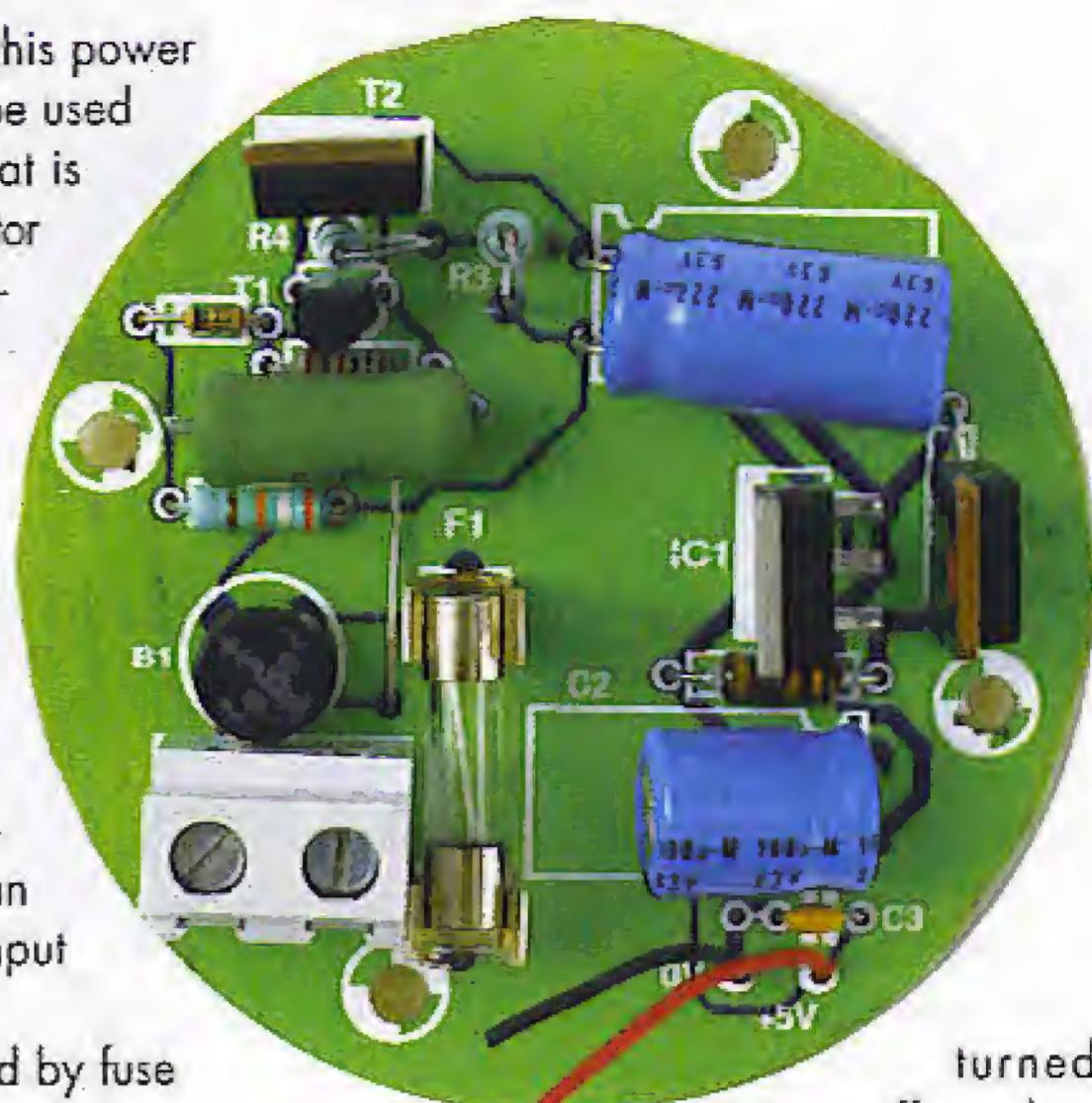
The power supply in this article is intended for exactly these situations, namely converting the mains voltage to a 5-V power supply voltage. The accompanying PCB fits exactly in a round wall socket enclosure.

A power supply is usually fitted with a transformer to reduce the voltage and also provide galvanic isolation between

the device and the mains. In this power supply a transformer cannot be used because of lack of space. That is why we use a step-down regulator here. A problem with most step-down regulators is that they cannot be supplied directly from the mains. Hence, in this schematic (**Figure 1**) we first create a rough power supply voltage of around 40 V using passive components and subsequently present it to step-down converter IC1. The converter can operate from a maximum input voltage of 45 V.

The mains voltage is first fused by fuse F1 and then converted to full rectified sine wave by the bridge rectifier.

FET T2 is used as a switch, which is

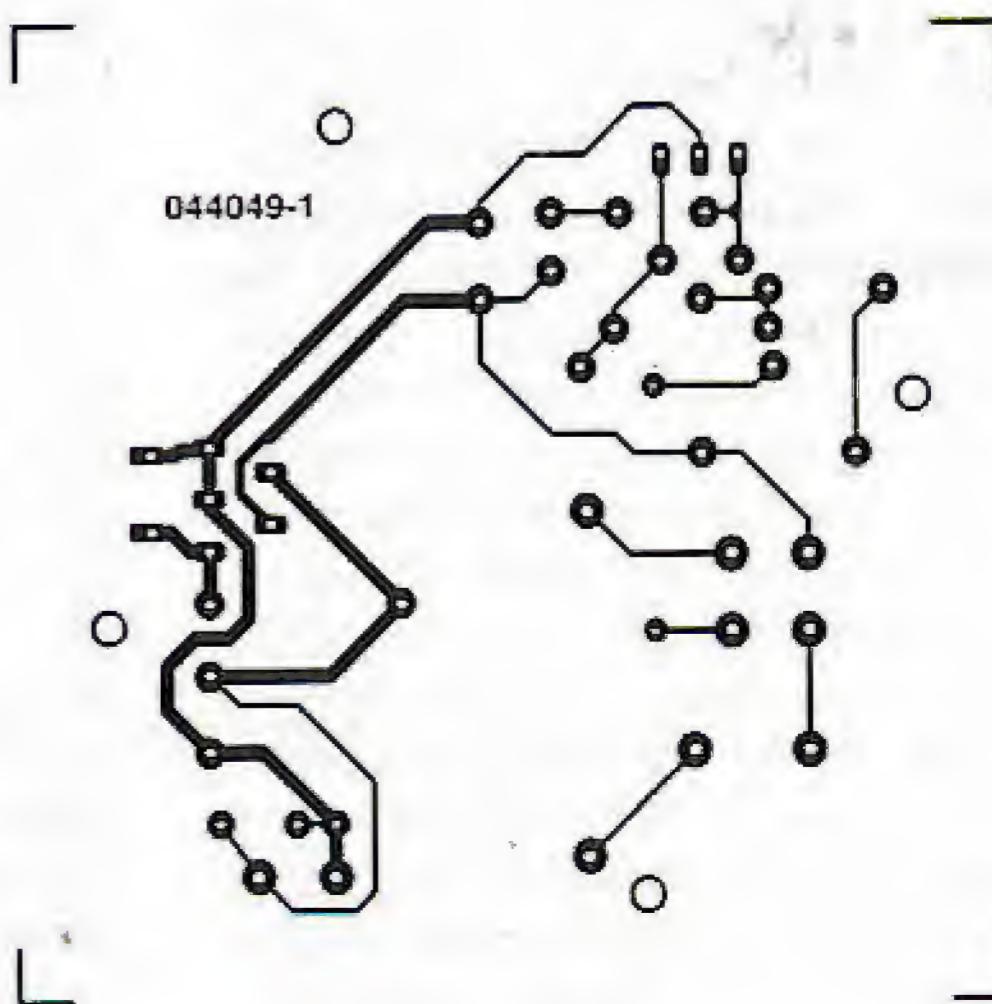
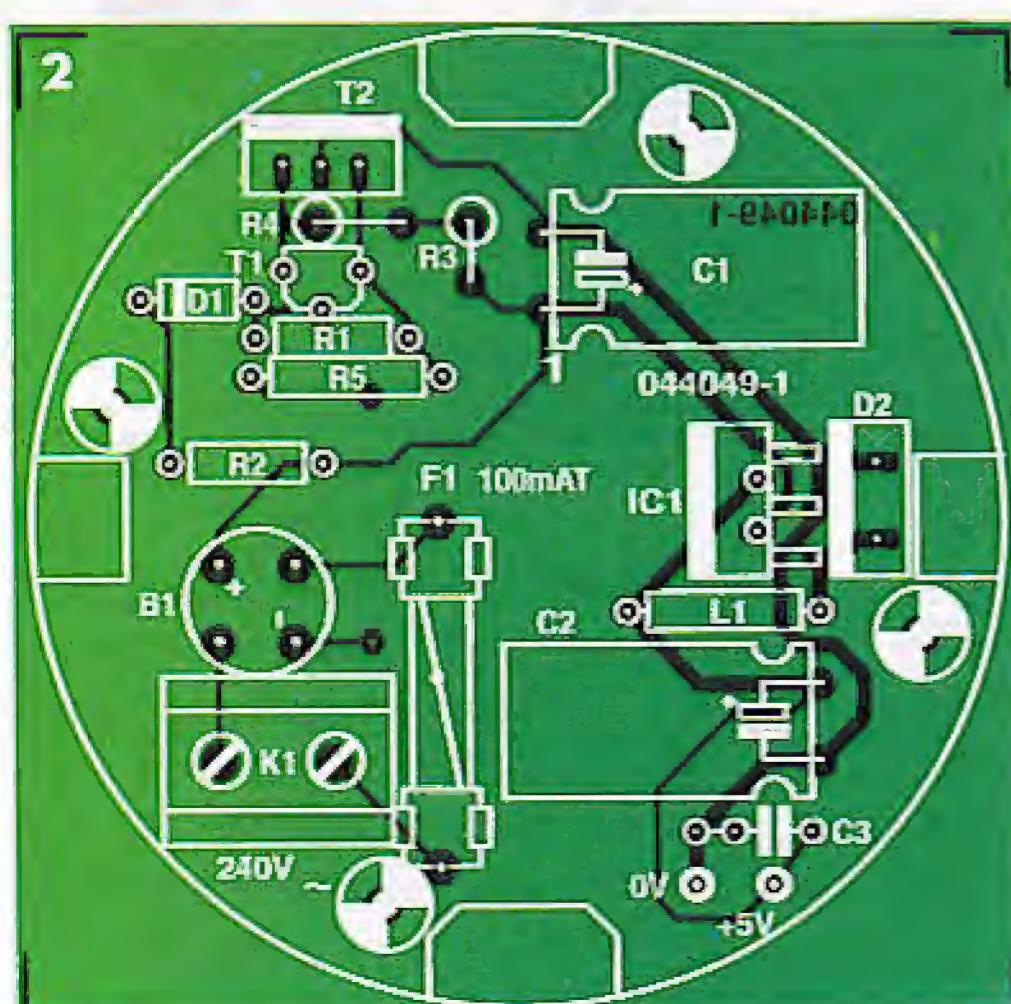
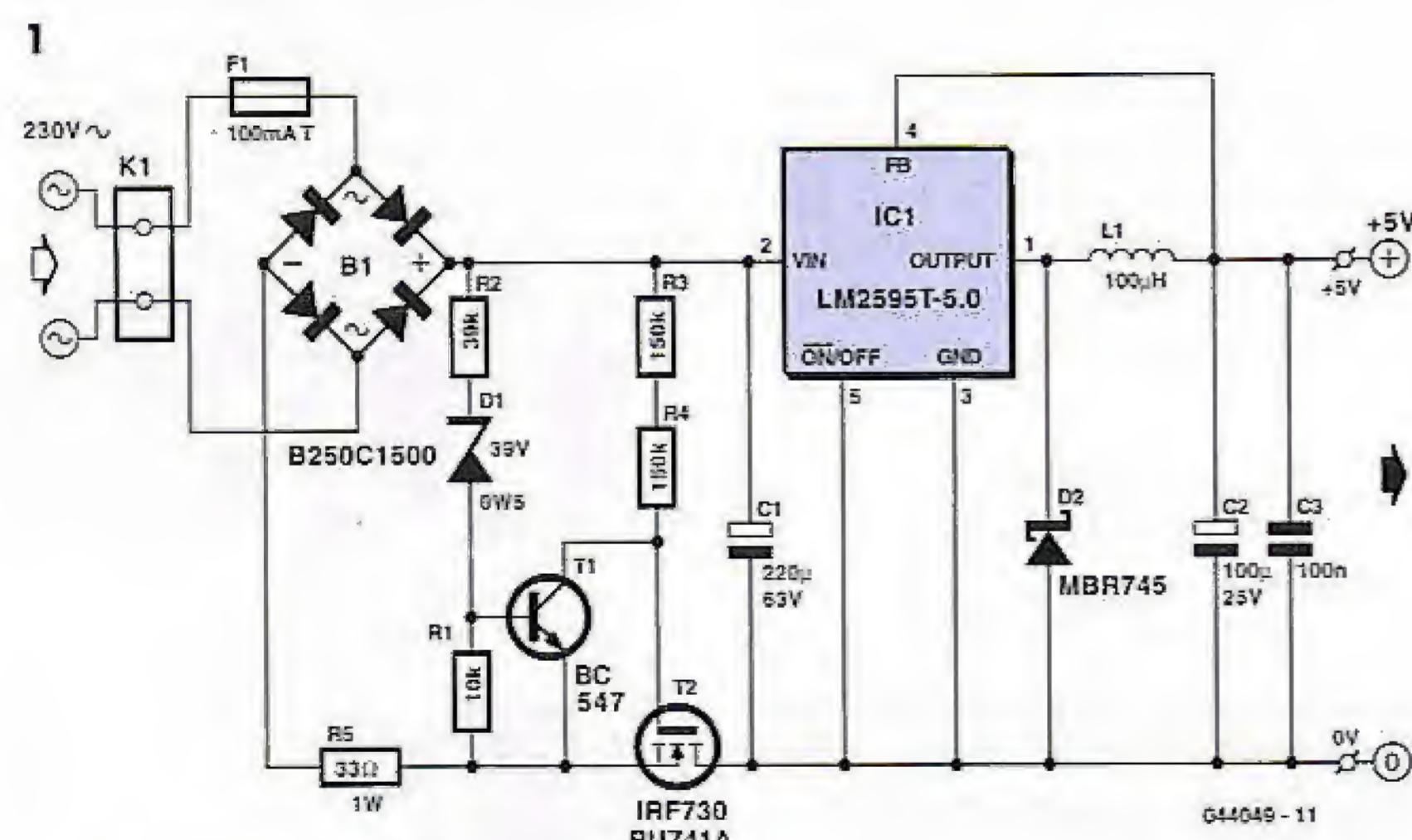


turned off when

the voltage is greater than 40 V. The gate of T2 is driven via R3 and R4. As soon as the voltage exceeds the value of 40 V, transistor T1 will conduct which causes the gate-drain voltage of T2 to be so small that T2 stops conducting. Because of this, electrolytic capacitor C1 cannot charge any further and the maximum voltage across C1 is therefore limited to about 40 V.

This voltage is converted by IC1 and surrounding components to a 5-V power supply voltage. The maximum output current is 1 A.

The PCB (**Figure 2**) that has been designed for the power supply fits, as mentioned before, in a round wall socket enclosure. Note that resistor R1 and the link have to be soldered first, then comes R5, in the air above R1 because of the tight space.



Populating the remainder of the PCB should not present any difficulties. When mounting the PCB, do note that it is directly connected to the mains, so make sure no conductive parts can be touched when the circuit is in use. The mounting

holes are separated less than 6 mm from the PCB traces so the board has to be secured with plastic screws in order to satisfy the safety requirements. Also, after fitting the board, a cover has to be mounted over the PCB so that it is impos-

sible to touch the PCB when the wall socket is opened. As always, you cannot be too careful when dealing with mains voltages!

(D44049-1)

## COMPONENTS LIST

### Resistors:

R1 = 10k $\Omega$   
R2 = 39k $\Omega$   
R3,R4 = 150k $\Omega$   
R5 = 33 $\Omega$

### Capacitors:

C1 = 220 $\mu$ F 63V radial  
C2 = 120 $\mu$ F 25V radial  
C3 = 100nF

### Semiconductors:

B1 = B250C1500, round case  
D1 = zener diode 39V, 0.5W  
D2 = MBR745  
IC1 = LM2595T-5.0

T1 = BC547B

T2 = IRF730 or BUZ41A

### Miscellaneous:

F1 = fuse, 100 mA (slow), with PCB mount holder and cap  
K1 = 2-way PCB terminal block, lead pitch 7.5mm  
L1 = 100 $\mu$ H choke  
PCB, available via The PCBShop

# I<sup>2</sup>C and SMBus

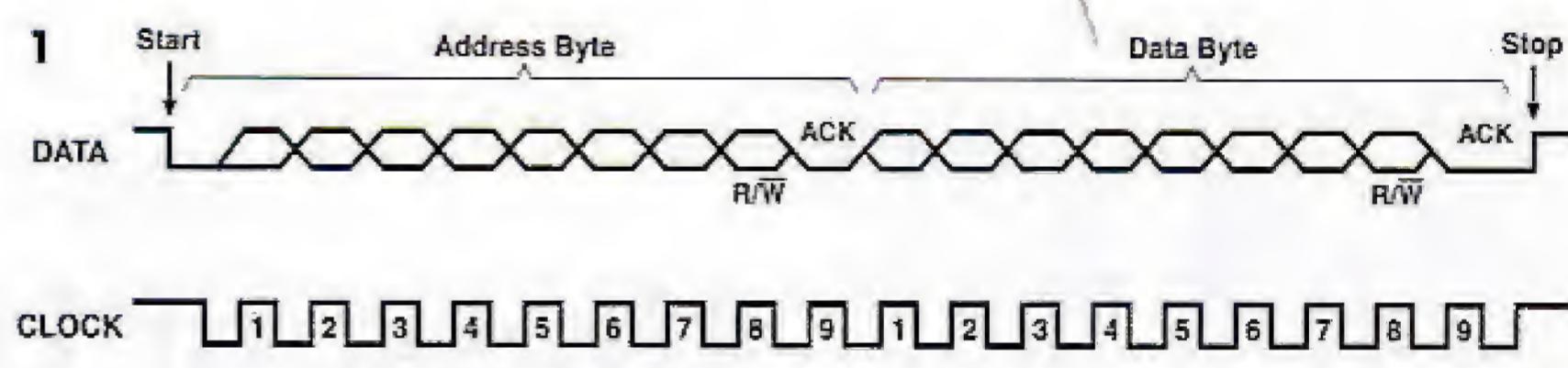
Paul Goossens

The I<sup>2</sup>C-bus has been dealt with before in *Elektor Electronics*. Most readers will know that this bus requires only two signals to communicate between, for example, a controller and one or more ICs in a circuit. We may also assume that it is well known that this bus was developed by Philips and is used mainly in televisions, video recorders, tuners, etc.

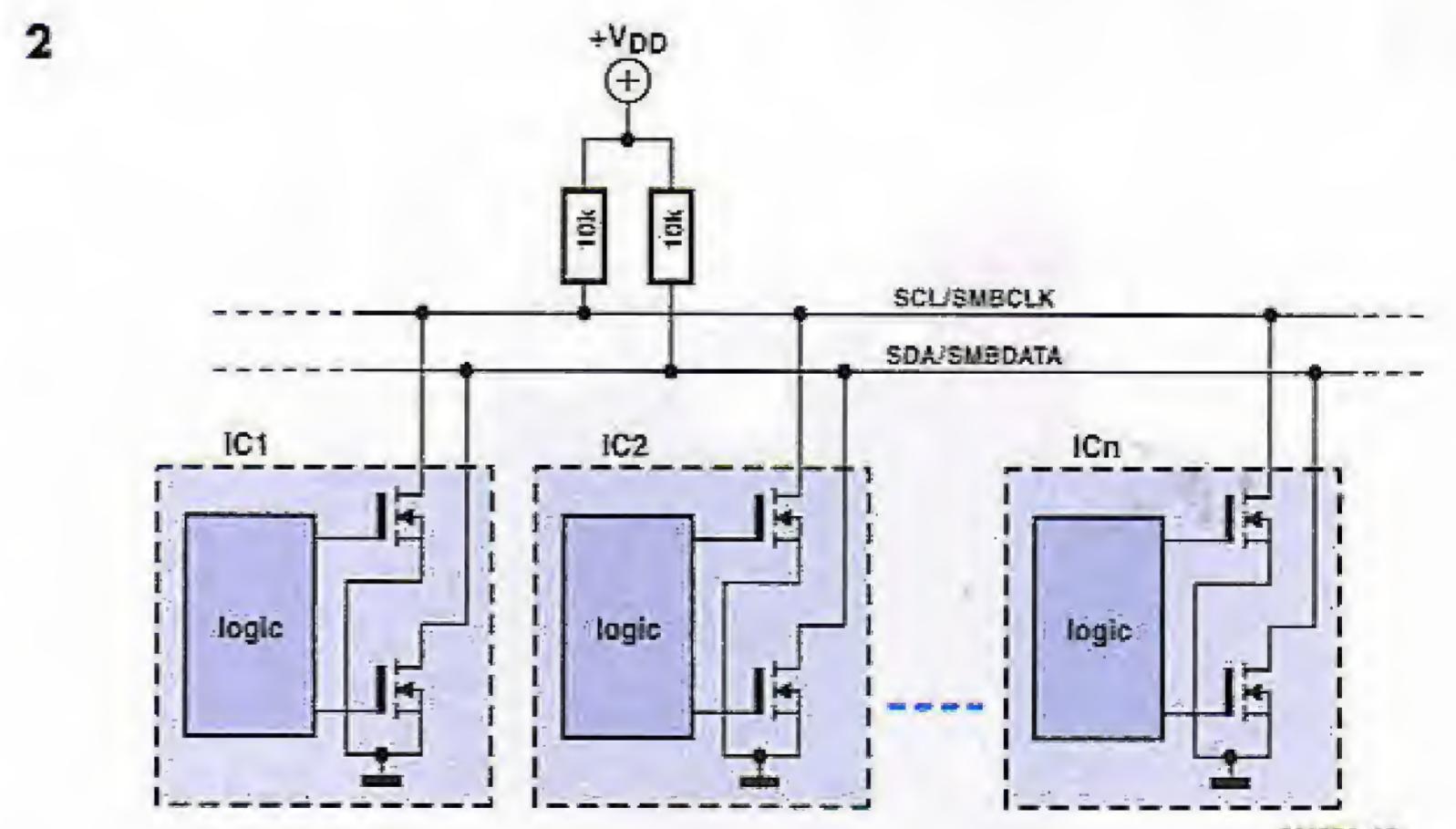
Unfortunately, the I<sup>2</sup>C-bus lacks a number of features that manufacturers of computer motherboards require. They therefore developed their own bus, which has been derived from the I<sup>2</sup>C-bus. This bus goes by the name SMBus (System Management Bus). The main task for the protocol is to provide communications between the processor and various temperature sensors, battery management/charging-chips and even memory modules, etc. in a PC. Because the SMBus has been derived from the I<sup>2</sup>C-bus, there are obviously a number of similarities. It is in many cases even possible to let components with an I<sup>2</sup>C-bus communicate with those with an SMBus and vice versa.

### The similarities

Both bus protocols make use of the same start and stop mechanism. A start-condi-



044054-11



044054-12

tion can be recognised by the falling edge on the data line while the clock line remains high. With a stop-condition, a rising edge appears on the data line while the clock line is high. These two conditions are the only situations where the data line may change level when the clock line is high. This can be seen in **Figure 1**.

Following the start condition there is the 7-bit address that has to be unique for each device connected to the bus. Another similarity is that the bus has a single pull-up resistor for each signal and the connected chips drive these signal lines with an open-source output, as can be seen in **Figure 2**. This forms a so-called wired-OR configuration. As soon as one

of the chips pulls a signal line to ground, the signal will have a low level, irrespective of what the other chips try to do.

### The differences

Naturally there are also a number of differences between the two protocols. We start with the clock speed. With I<sup>2</sup>C-bus this can vary from 0 to 100 kHz in NORMAL mode and up to 400 kHz in FAST mode. With the SMBus, the clock speed has to be between 10 kHz and 100 kHz. The minimum speed is the result of an additional provision of the SMBus. If the clock line is low for more than 35 ms a time-out situation occurs. All chips on the bus have to detect this time-out and ignore all communications until a valid start-condition occurs. This prevents one chip from disabling the entire communication of the bus.

Another difference is the specified levels for logic high and logic low. In the I<sup>2</sup>C-specifications a low level is defined as 1.5 V, while with the SMBus a level less than 0.8 V is required. The high-level is different as well: with I<sup>2</sup>C this has to be a minimum of 3 V, while with the SMBus a

## Finding the correct signals in a PC

To experiment (at your own risk!) with the SMBus (and I<sup>2</sup>C) it is necessary to find the signals Vcc, GND, SMBCLK and SMBDATA in the PC. The easiest place to find these signals is on the memory modules. Every memory module has besides the memory chips a small EEPROM, which contains the necessary information about the memory module for the BIOS. These EEPROMs all communicate via the SMBus. This is therefore the ideal location to tap into the required signals.

level of 2.1V or higher is considered a high level.

This difference in the required voltage levels would indicate that both protocols cannot be used with each other. In practice this is not so much of a problem, since most chips will generate signals that range from about zero to nearly the power supply voltage.

The outputs of an SMBus IC are specified to be able to sink at least 100  $\mu$ A, while I<sup>2</sup>C requires a minimum sink current of 3 mA. All this is related to the fact that the

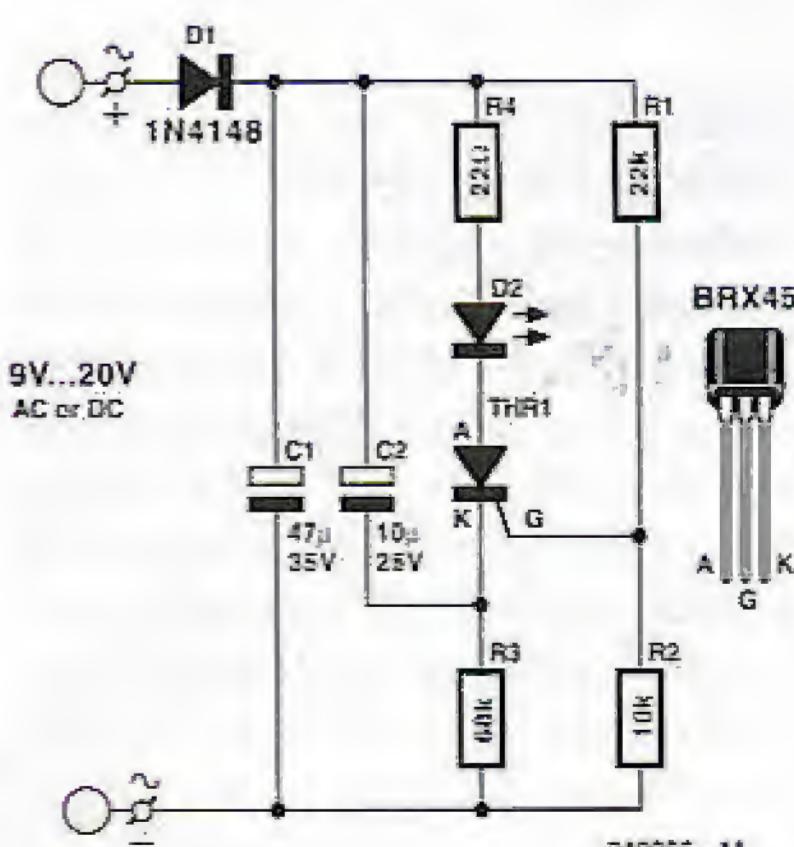
SMBus is also used in laptops and therefore have to be a little thrifty with power consumption. This means a higher pull-up resistor is required. A value of 10 k $\Omega$  is usually a good starting value so that both SMBus-ICs and I<sup>2</sup>C-ICs can communicate together on the same bus.

There are also a number of subtle differences, such as maximum bus capacitance, rise- and fall-times, etc, but nothing that will prevent you from connecting an I<sup>2</sup>C chip to the SMBus or the other way around.

(040054-1)



## Unusual LED Blinker



Robert Edlinger

This LED blinker manages with only a few components and is dimensioned to operate from an ac supply in the range of 4–16 V (6–24 V dc). As its current con-

sumption is less than 1 mA, it's also suitable for long-term battery-powered operation. It thus offers several advantages in various applications, compared with using the well-known 555 timer IC as an astable multivibrator. Depending on the

values of the timing components, the blinking rate ranges from 1 to 1.5 Hz. Although the duration of each blink is only a few milliseconds, a high brightness level is achieved by using a relatively high LED current. There are numerous

potential applications for this circuit in model railway systems, in both stationary and moving equipment.

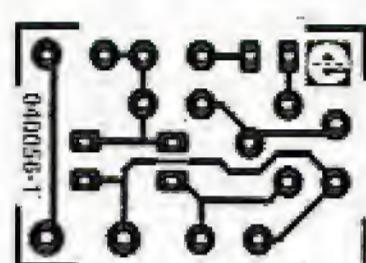
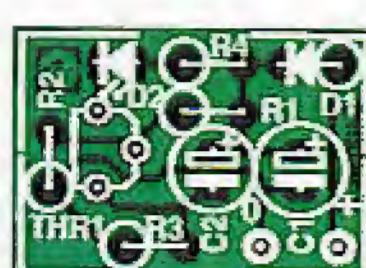
An small, inexpensive thyristor serves as an oscillator. Voltage divider R1/R2 holds the voltage on the gate lead (G) to approximately 20 % of the supply voltage. Capacitor C2 charges via R3. This causes the voltage on the cathode (K) to drop until it is around 0.5 V to 1 V below the gate voltage (depending on the thyristor type), at which point the gate current is sufficient to trigger the thyristor.

Capacitor C2 then discharges via the cathode-anode junction, R4 and the LED. The only purpose of R4 is to limit the LED current to a permissible value. After C2 has discharged, the cathode-anode junction is again cut off, since the resistance of R3 is so high that the sustaining current level (which is less than 5 mA for the BRX45-57 family) is not achieved. The next blink cannot occur until C2 has again charged.

The blinking rate can be adjusted over a wide range by varying the values of R3 and/or C2. The listed thyristor is recom-

mended for use in this circuit due to its high gate current sensitivity (<0.2 mA). Practically any model railway transformer or bell transformer can be used as a power source. A half-wave rectifier and small filter capacitor are adequate for rectifying the supply voltage.

10-00056-03



# COMPONENTS LIST

### Resistors:

$$\begin{aligned}R_1 &= 22\text{k}\Omega \\R_2 &= 10\text{k}\Omega \\R_3 &= 68\text{k}\Omega \\R_4 &= 22\Omega\end{aligned}$$

## Capacitors

$C_1 = 47\mu F \text{ } 35V$

### Semiconductors:

D1 = 1N4148  
D2 = low-current LED  
THD1 = BRV15

#### Miscellaneous:

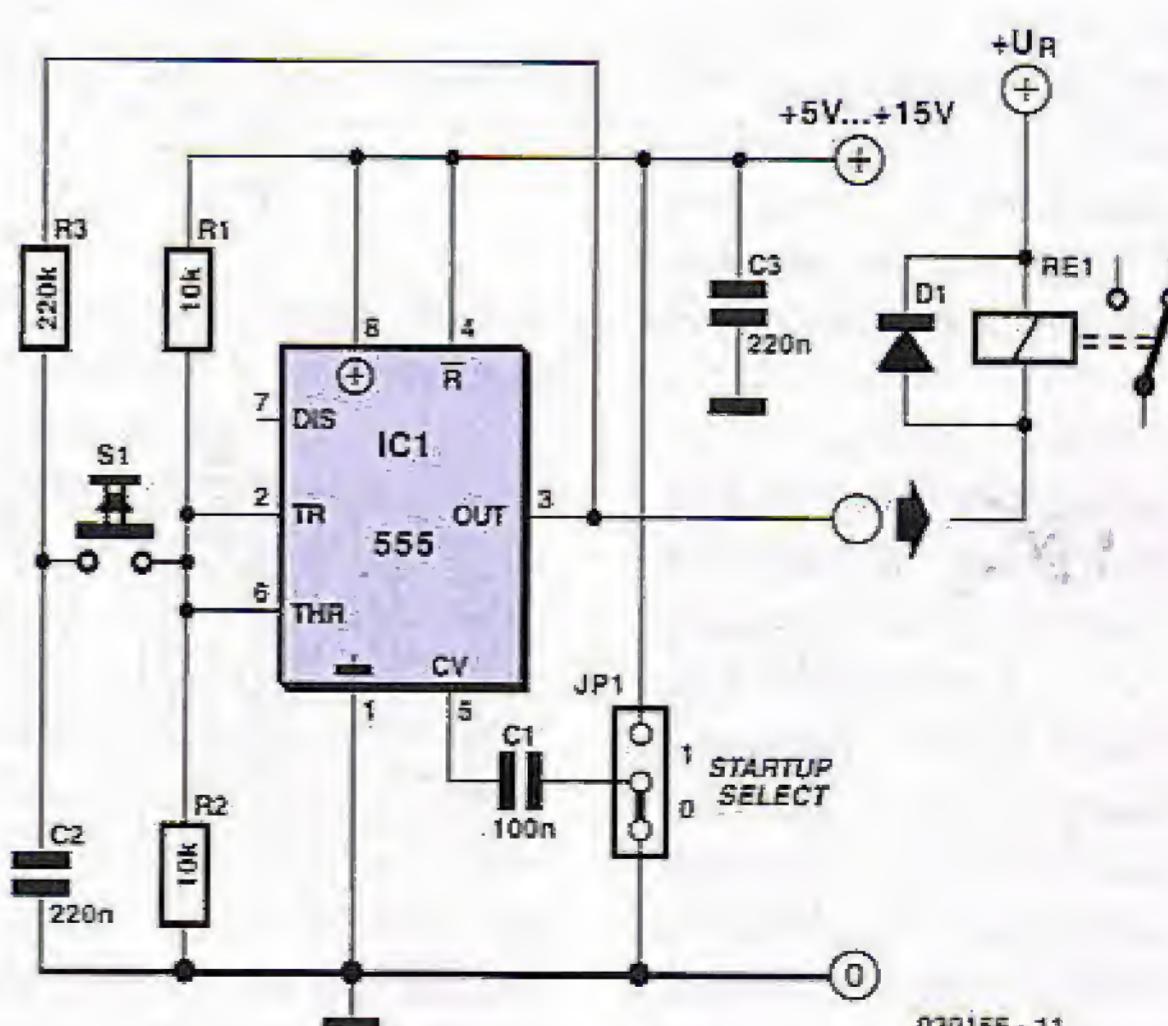
PCB, order code 040056-1 from The PCBShop

# On/Off Button

Ger Langezaag

It features at least once in every Small Circuits collection: the 555 timer. In this simple circuit we give the chip a little more attention than usual (refer to 'The Eternal 555' in the July/August 2004 issue). It is astonishing what can be built with a 555. Here at *Elektor Electronics* we are always infatuated with simple circuits using this IC, such as the one shown here. The 555 is used here so that a single pushbutton can operate a relay. If you press the button once, the relay is energised. When you press it again the relay turns off. In addition, it is possible to define the initial state of the relay when the power supply is switched on.

The design is, as previously mentioned, very simple. Using R1 and R2, the threshold and trigger inputs are held at half the power supply voltage. When the voltage at the threshold pin becomes greater than  $2/3$  of the power supply voltage, the output will go low. The output goes high when the voltage at the



trigger input is less than 1/3 of the power supply voltage. Because C2, via R3, will eventually have the same level as the output, the output will toggle whenever the pushbutton is pressed. If, for example, the output is low, the level of the trigger input will also

become low and the output will go high! C1 defines the initial state of the relay when the power is applied. If the free end of C1 is connected to  $V_{CC}$ , then the output is high after power up; the output is low when C1 is connected to ground.

102015-1

Paul Goossens

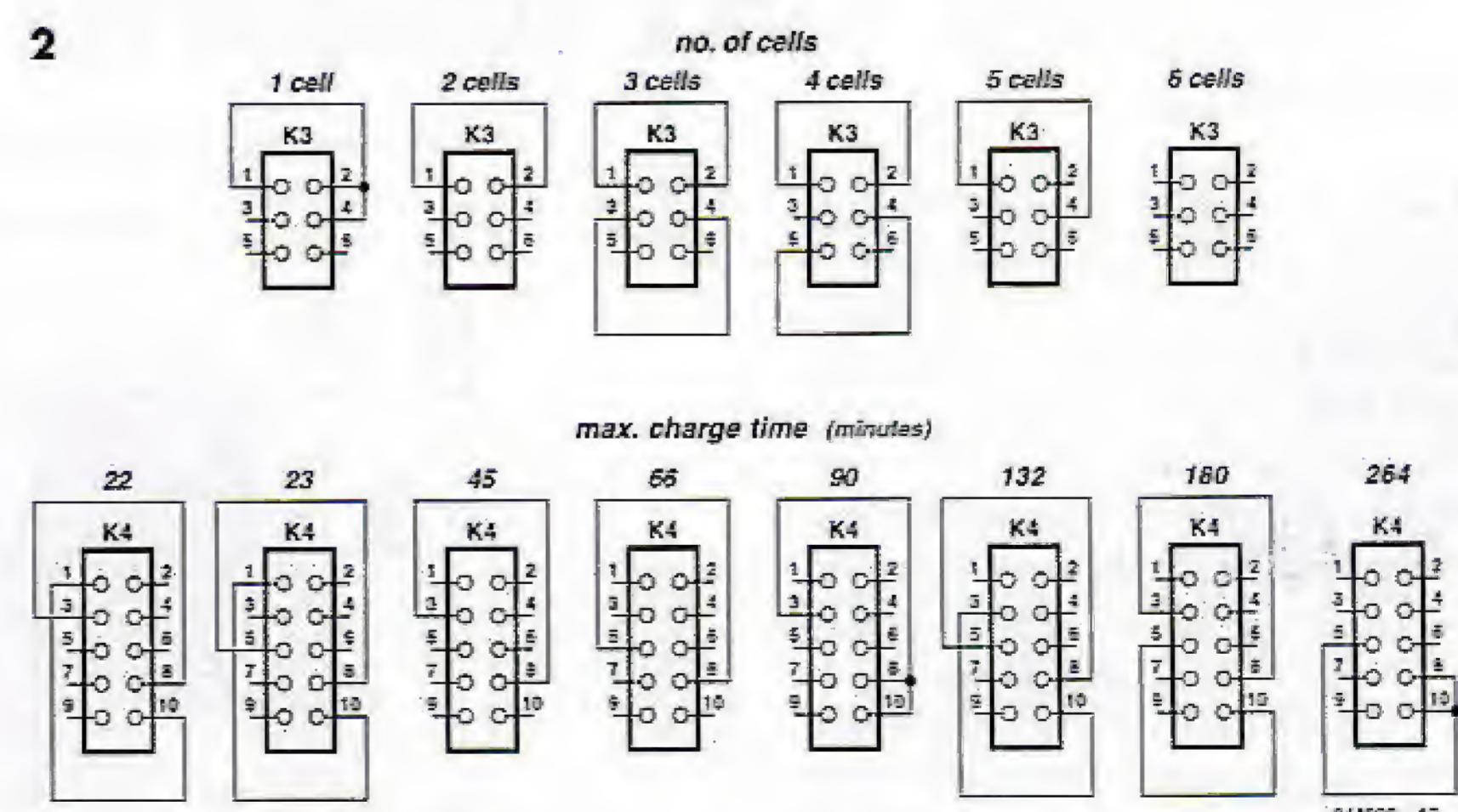
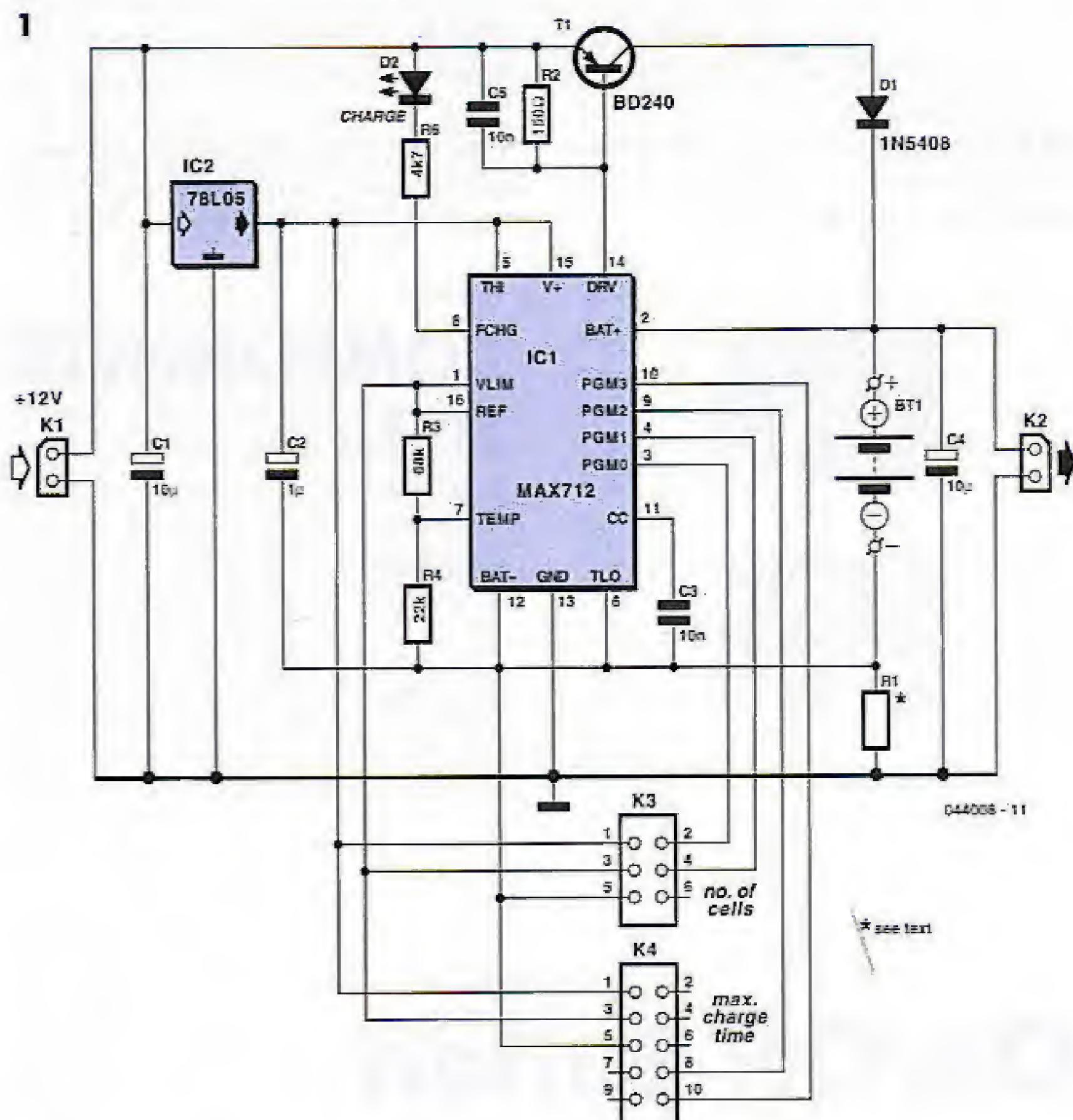
It is impossible to imagine present day society without any batteries. Count the number of gadgets in your house that are powered from batteries, you will be stunned by the number of batteries you will find.

The majority of these devices use penlight batteries and if you're a little environmentally conscious you will be using rechargeable batteries. A few years ago these batteries were invariably NiCd types. However, these batteries suffer from a relatively high rate of self-discharge and from the so-called memory-effect. It is now more common to use NiMH batteries. The advantage is that these batteries do not suffer from the memory-effect and generally also have a much higher capacity, so that they last longer before they have to be recharged again.

From the above you can conclude that every household these days needs, or could use, a battery charger. A good charger needs to keep an eye on several things to ensure that the batteries are charged properly. For one, the charger has to make sure that the voltage per cell is not too high. It also needs to check the charging curve to determine when the battery is fully charged. If the charging process is taking too long, this is an indication that something is wrong and the charger must stop charging. Sometimes it is also useful to monitor the temperature of the cells to ensure that they do not get too hot.

The circuit presented here is intended for charging NiMH batteries. The MAX712 IC used here contains all the necessary functionality to make sure that this happens in a controlled manner. **Figure 1** shows the schematic of the charger. The heart of the circuit is easily recognised: everything is arranged around IC1, a MAX712 from Maxim. This IC is available in a standard DIP package, which is convenient for the hobbyist because it can be directly fitted on standard though-hole prototyping board.

IC1 uses T1 to regulate the current in the battery. R1 is used by IC1 to measure the current. While charging, IC1 attempts to maintain a constant voltage, equal to 250 mV, across R1. By adjusting the



value of R1 the charging current can be set. The value of R1 can be calculated using the formula below:

$$R1 = 250 \text{ mV} / I_{\text{charge}}$$

For a charging current of 1 A, the value of R1 has to be  $250 \text{ mV} / 1 \text{ A} = 0.25 \Omega$ . The power dissipated by R1 equals  $U \times I = 0.25 \times 1 = 250 \text{ mW}$ . A 0.5-watt

resistor will therefore suffice for R1. Transistor T1 may need a small heatsink depending on the charging current and supply voltage.

IC1 needs a small amount of user input regarding the maximum charging time and the number of cells in the battery to be charged. IC1 has four inputs, PGM0 to PGM3, for this purpose. These are not ordinary digital inputs (which recognise

only 2 states) but special inputs that recognise 4 different states, namely V+, Vref, BATT- or not connected. To make this a little bit more user friendly, we've brought out the necessary connections to 2 connectors (K3 and K4). A number of dongles have been made (**Figure 2**) that can be plugged into these connectors and set the number of cells and the maximum charging time. When determining the maximum charging time we have to take into account the charging current and the capacity of the

cells that are connected. The charging time can be calculated with the formula:

$$T_{\text{charge}} = C_{\text{cell}} / I_{\text{charge}} \times 1.2$$

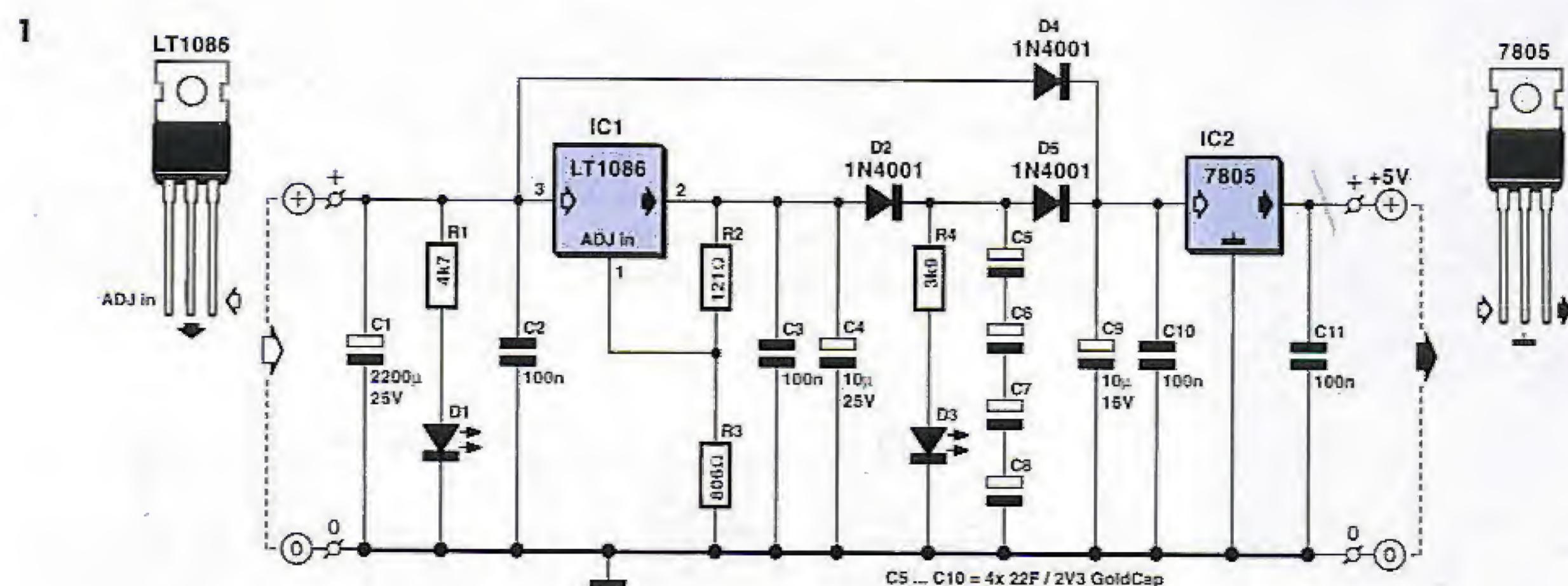
where  $C_{\text{cell}}$  is the capacity in Ah (e.g., 1200 mAh = 1.2 Ah).

After the nominal charging time has been calculated, we can use the first dongle that has a value that is equal or greater than the calculated charging time. For example, if we calculated a maximum charging time of 38 minutes, we have to

select the dongle for 45 minutes. When IC1 is replaced by a MAX713, the charger becomes suitable for charging NiCd batteries (but not suitable for NiMH batteries any more!). The only difference between these two ICs is the value of the detection point at which the cell(s) are considered to be completely charged. The ICs are otherwise identical with regard to pin-out, method of adjustment, etc. To make it easy to swap between the ICs, we recommend an IC-socket for IC1.

(04408-1)

## On-Train Radio Camera



030419 - 11

Bernd Oehlerking

A radio camera on a model railway should transmit constantly while the train is moving and continue transmitting for a few minutes after the train stops. But if the train starts up again after a relatively long halt, imagery should be transmitted immediately. Consequently, the power source for the camera cannot be rechargeable batteries (since they take too long to charge), nor can it be primary batteries (for environmental reasons). Instead, GoldCaps provide a good alternative. They can be charged in no time flat, and they assure sufficient reserve power for operating the radio camera for a few minutes.

Coming from the left in the schematic shown in **Figure 1**, the dc voltage

arrives at the supply circuit and is buffered by capacitor C1, which bridges brief power interruptions.

The actual reserve power source consists of four GoldCaps connected in series, each rated at 22 F / 2.3 V, which yields a net capacitance of 5.5 F / 9.2 V. The maximum charging voltage must never exceed 9.2 V. This is ensured by a modern adjustable low-drop voltage regulator (LT1086), which is set to a nominal output voltage of 9.57 V by resistors R2 and R3 (since there is an 0.6-V voltage drop across D5). The LT1086 can handle a current of 1.5 A (with current limiting), so even completely empty GoldCaps can be charged in a few seconds. Whenever the dc voltage is present, the GoldCaps are charged via D2.

When the dc voltage is present, the camera is not powered from the Gold-

Caps, but instead directly from the track via D4. Diode D5 prevents this voltage from reaching the bank of capacitors, and D4 prevents the GoldCaps from discharging via the track when no voltage is present on it. D4 and D5 thus form a sort of OR gate.

The radio camera used by the author requires 5 V and draws a current of approximately 70 mA. This means the circuit must have an output stage consisting of a 'normal' 7805 fixed voltage regulator and the usual capacitors (C9, C10, C11).

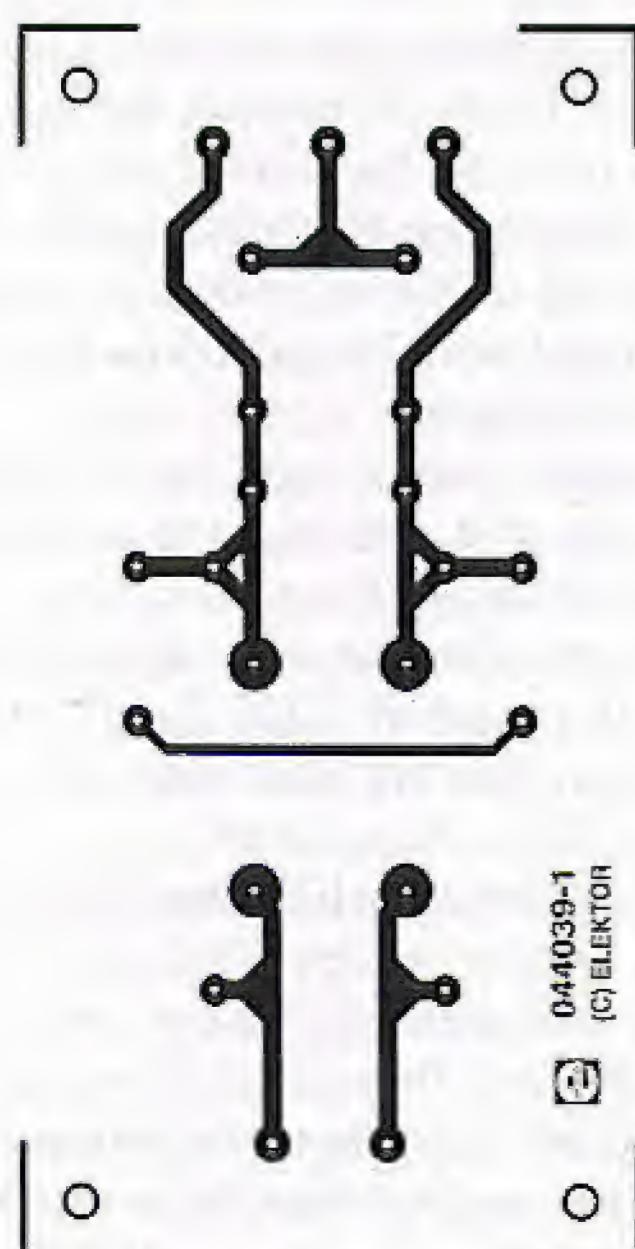
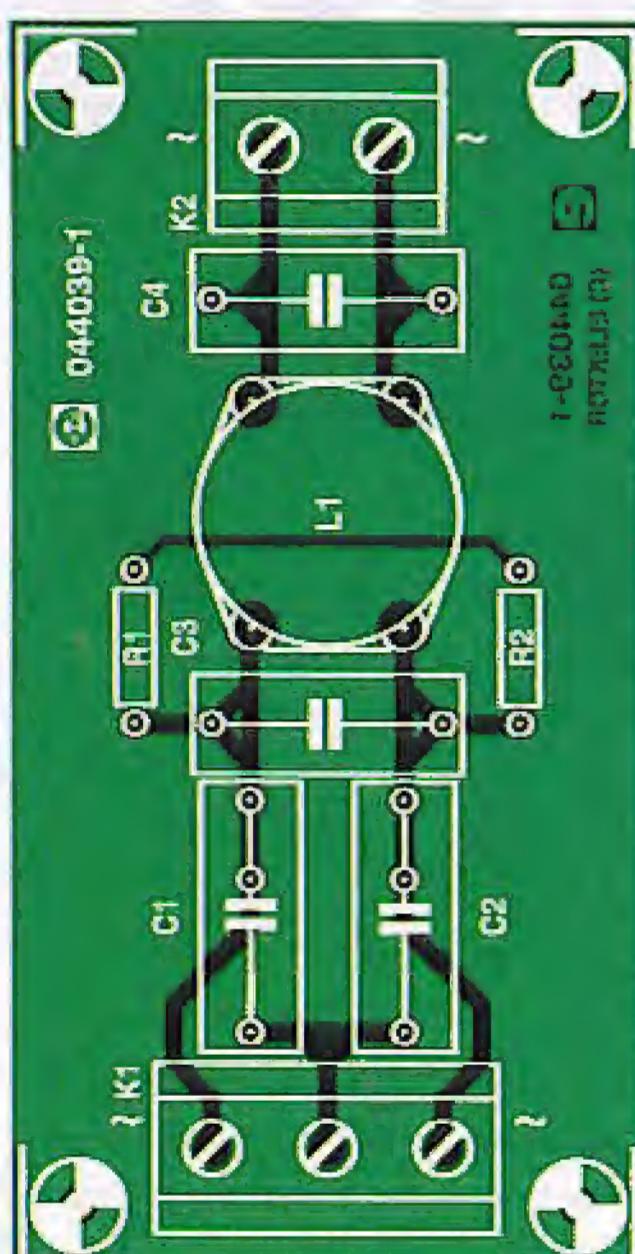
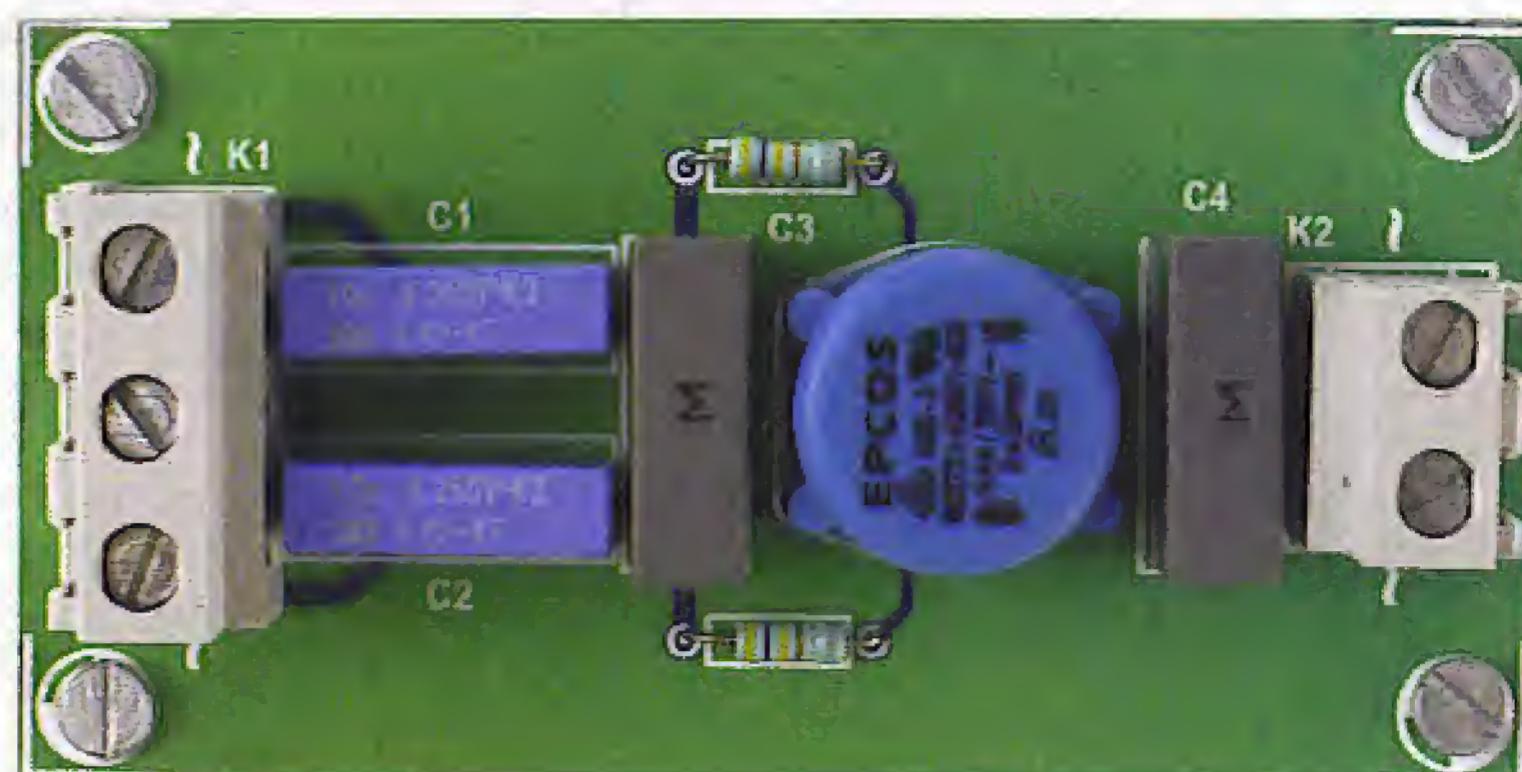
The two low-current LEDs respectively indicate whether voltage is present on the track and whether the storage capacitors are charged. They can also be omitted. The 100-nF capacitors must be placed as close as possible to the voltage regulators.

(030419-1)

# Universal Mains Filter

Ton Giesberts

There are plenty of mains filters available, with or without sockets, with or without a switch, etc. In any case, this filter is very versatile as far as the maximum working current is concerned. It so happens that the footprint of the coil remains the same for different currents. Depending on the required specification, you can use a specific coil (which the manufacturer calls a 'Current-COMPENSATED Ring Core Double Choke').

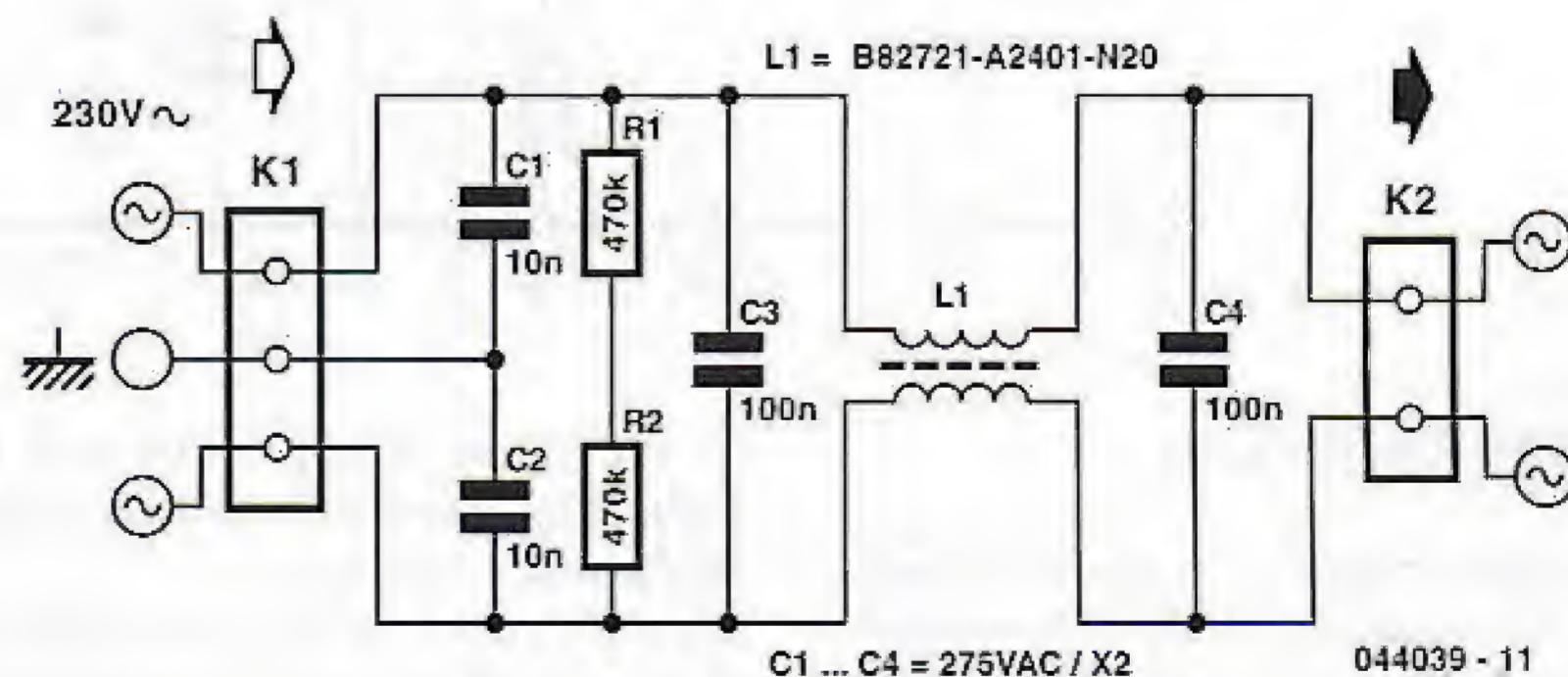


The table below lists a suitable range of coils made by Epcos. When we designed the PCB we chose the smallest size that still gave a wide selection of maximum currents.

Be careful that you don't use a vertical version of the coil. These appear to be pin-compatible, but they have different

connections. They would cause a severe short-circuit on this PCB! For this reason we haven't included them in the table (they have a K instead of an A in their order code).

This filter is suitable for use up to 3.6 A (a good 800 VA). In practice there should be no need to use different val-



<b>I<sub>R</sub></b> <b>(A)</b>	<b>L<sub>R</sub></b> <b>(mH)</b>	<b>L<sub>S,typ.</sub></b> <b>(μH)</b>	<b>R<sub>S,typ.</sub></b> <b>(mΩ)</b>	<b>Ordering code</b> <b>horizontal version</b>
0.4	39	450	2000	B82721-A2401-N20
0.4	27	270	1700	B82721-A2401-N21
0.5	18	260	1500	B82721-A2501-N1
0.7	10	90	600	B82721-A2701-N20
1.2	6.8	70	280	B82721-A2122-N20
1.5	3.3	37	190	B82721-A2152-N1
2.0	1.0	13	90	B82721-A2202-N1
2.6	0.4	6	60	B82721-A2262-N1
3.6	0.4	6	35	B82721-A2362-N1

ues for the capacitors. You should make sure that you obtain the correct lead spacing and that they're X2 types. For the 100 nF capacitors provision is only made for a lead spacing of 15 mm (as these are the most common). For the 10 nF capacitors you can use either 10 or 15 mm types.

A final warning: always take great care when working with mains voltages!

(044039-1)

## COMPONENTS LIST

### Resistors:

R1,R2 = 470k $\Omega$

### Capacitors:

C1,C2 = 10nF 27.5 V<sub>AC</sub> X2, lead pitch 10 or 15mm

C3,C4 = 100 n/275 V<sub>AC</sub> X2, lead pitch 15mm

### Inductors:

L1 = B82721-A2401-N20, Epcos (Farnell 976-477)

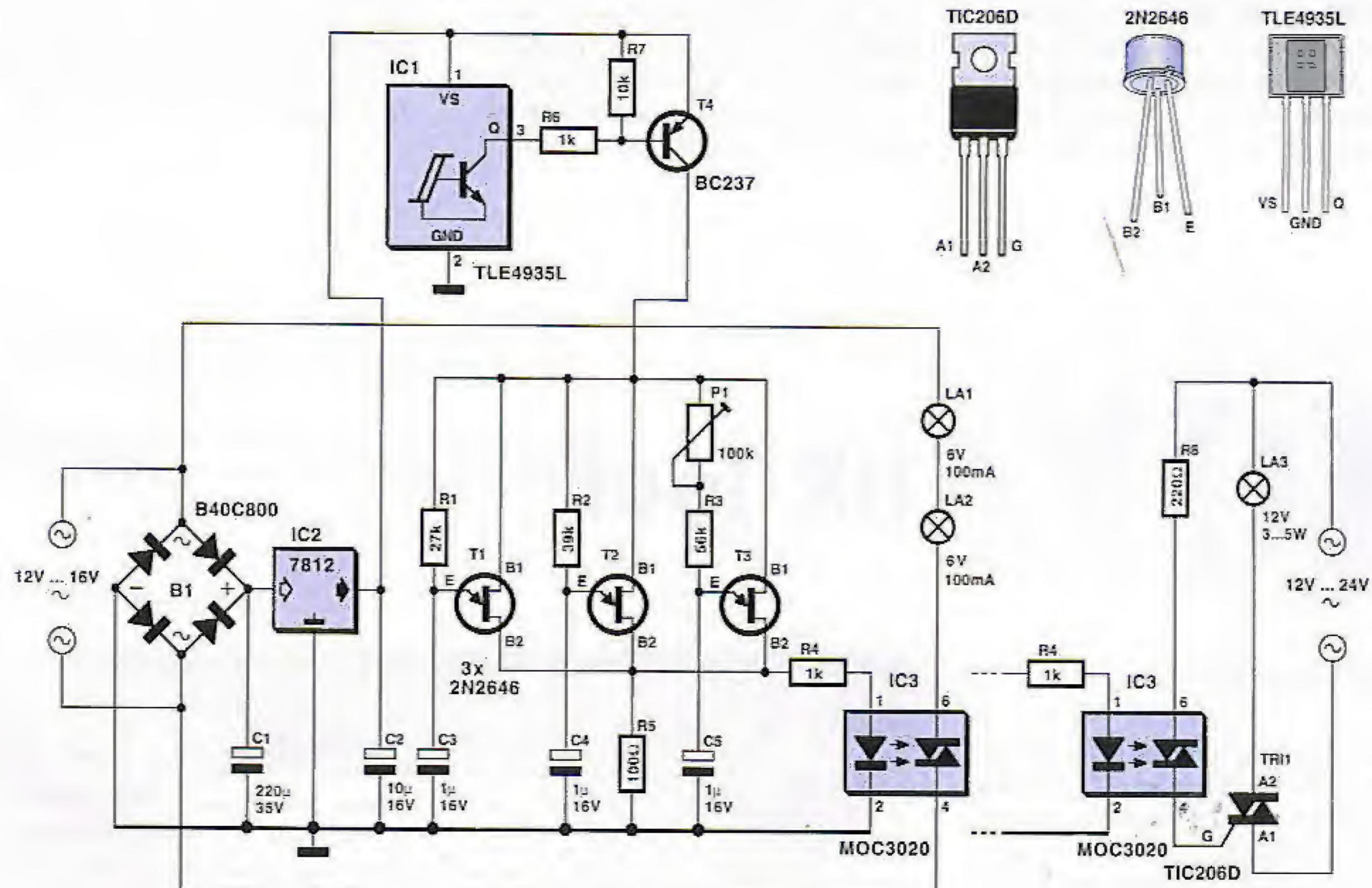
### Miscellaneous:

K1 = 3-way PCB terminal block, lead pitch 7.5mm

K2 = 2-way PCB terminal block, lead pitch 7.5mm

# Flickering Light II

016



040059 - 11

**Robert Edlinger**

In the July/August 2004 issue we published a flickering light for use in models that uses a microcontroller to minimise the component count. Regardless of whether you want to effectively imitate a house fire, a campfire, or light from welding, the circuit described here fills the bill without using a microcontroller, although it does use a larger number of components

(including some truly uncommon ones).

The circuit is based on three oscillators, which are built using unijunction transistors (UJTs). Each oscillator has a different frequency. The output voltages are mixed, which produces the flickering effect. A unijunction transistor consists of an n-type bar of silicon between two ohmic (non-barrier) base contacts (B1 and B2). The effective resistance is controlled by

the p-type emitter region. The designation 'transistor' is a somewhat unfortunate choice, since it cannot be used for linear amplification. UJTs are suitable for use as pulse generators, monostable multivibrators, trigger elements and pulse-width modulators. If a positive voltage is applied to the emitter (E), the capacitor charges via the resistor. As soon as the voltage on the emitter reaches approximately half the supply voltage (for a

2N2645, the value lies in the range of 56–75 %), the UJT ‘fires’ and the capacitor discharges via base B1 and the resistor, generating a positive pulse. The UJT then returns to the non-conduct state, and the process just described repeats periodically. The frequency can be approximately given by the formula

$$f = 1/(RC)$$

The frequency is independent of the value of the supply voltage (which must not exceed 35 V). The maximum emitter blocking voltage is 30 V, and the maximum permissible emitter current is 50 mA. The values of resistors R1, R2 and R3 can lie between 3 kΩ and 500 kΩ. If necessary, the frequency can be varied over a range of 100:1 by using a trimpot instead of a fixed resistor.

The frequencies from the three pulse generators are mixed by connecting them to the IR diode of a triac optocoupler via R4. The optocoupler, a type MOC3020, K3030P or MCP3020, can handle a maximum load current of 100 mA. The triac triggers at irregular intervals and generates the desired flickering light in the two small lamps, L1 and L2, which

are connected in series to the transformer secondary.

The light effect can be noticeably improved by using a MOC3040, which contains a zero-voltage switch, since it generates irregular pauses of various lengths when suitable frequencies occur in the individual oscillators. The zero-voltage switch does not switch while the current is flowing, but only when the applied ac voltage passes through zero. An integrated drive circuit (zero crossing unit) allows full half-waves or full cycles to pass (pulse-burst control). Due to the flickering effect arising from its switching behaviour, it is not suitable for normal lighting, but here this is just what we want. This version of the optocoupler is also designed for a maximum current of 100 mA.

For a small roof fire or the light of a welding torch in a workshop, two small incandescent lamps connected in series and rated at 6 V / 0.6 A (bicycle taillight bulbs) or a single 12-V lamp (rated at 100 mA) is adequate. If it is desired to simulate a large fire, a triac (TIC206D, rated at 400 V / 4 A, with a trigger current of 5 mA) can be connected to the output of the circuit and used to control a

more powerful incandescent lamp. As continuous flickering loses its attraction for an interested observer after a while (since no house burns for ever, and welders also take breaks), it's a good idea to vary the on and off times of the circuit. This is handled by a bipolar Hall switch (TLE4935L), which has such a small package that it can fit between the sleepers of all model railway gauges, including Minicub (Z Gauge), or even placed alongside the track if a strong permanent magnet is used. If a magnet is fixed somewhere on the base of a locomotive such that the south pole points toward the package of the Hall switch (the flattened front face with the type marking), the integrated npn transistor will switch on and pull the base of the external pnp transistor negative, causing the collector-emitter junction to conduct and provide the necessary ‘juice’ for the unijunction transistors. If another traction unit whose magnet has its north pole pointing toward the Hall switch passes a while later, the switch will be cut off and the flickering light will go out. Of course, you can also do without this form of triggering and operate the device manually.

(04009-1)



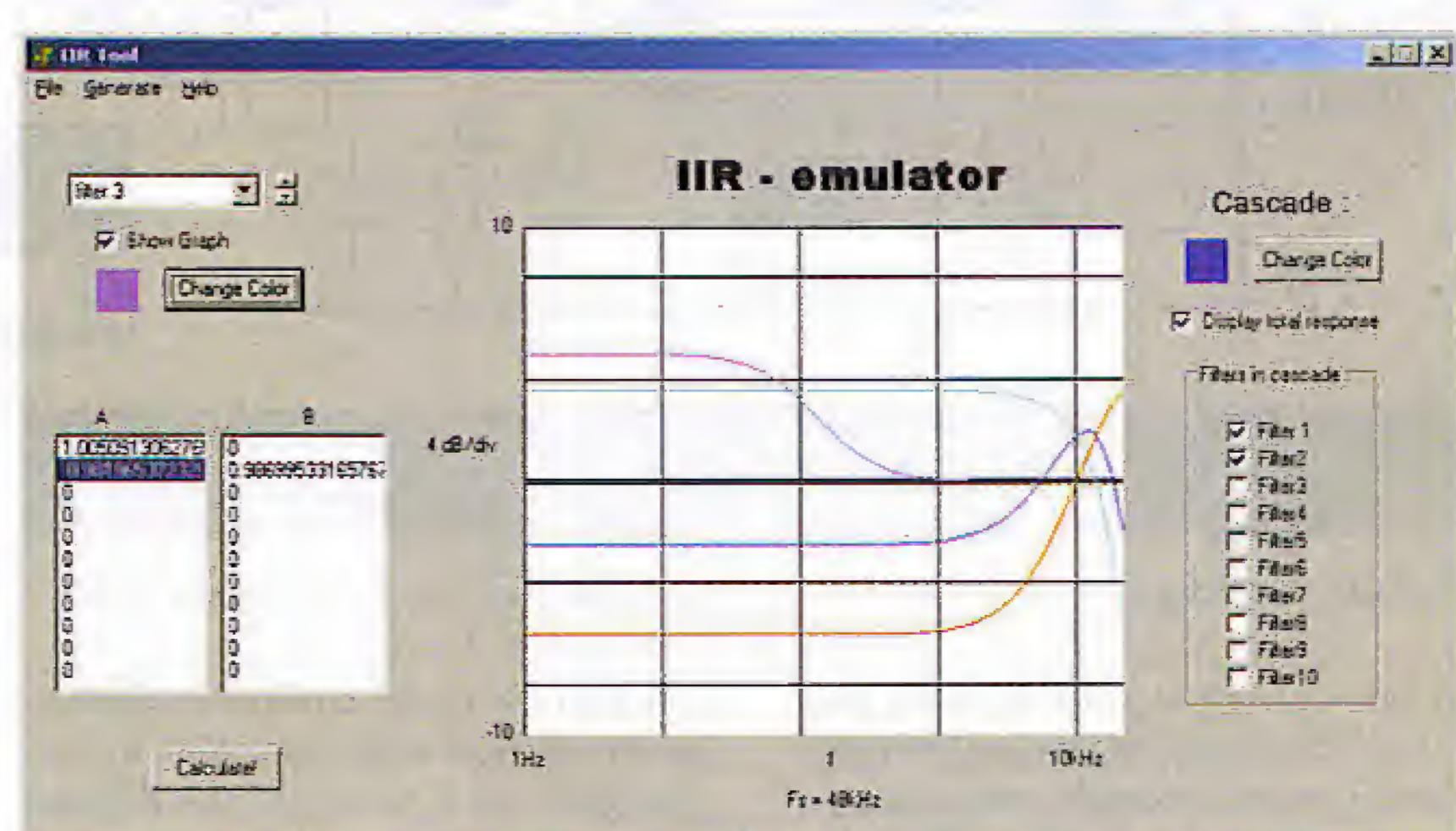
## IIR Tool

Paul Goossens

In the digital domain, analogue signals can be easily manipulated without requiring different hardware for each operation (as is necessary for analogue circuits). Other important advantages are that no noise is added during the operation (provided it is programmed correctly) and that mathematical algorithms are easier to implement.

Unfortunately, the design of a digital filter is not that straightforward. There are several methods for implementing a digital filter. A relatively efficient filter implementation is the IIR (Infinite Impulse Response) type. The filter is mathematically represented as:

$$x[n] = a_0 \cdot y[n] + a_1 \cdot y[n-1] \dots - b_1 \cdot x[n-1] \\ - b_2 \cdot x[n-2] \dots$$



Where  $x[n]$  is the output signal and  $y[n]$  is the input signal.

The values of the coefficients  $a_x$  and  $b_x$  determine the transfer function and therefore

the characteristics of the filter. Calculating the coefficients for a particular filter is often a stumbling block for designers. To make this task much easier, we

have written a program that not only calculates the coefficients for simple filters, but can also determine the frequency characteristic of IIR filters where the user calculated the coefficients themselves. This software is available from the Free Downloads section at [www.elektor-electronics.co.uk](http://www.elektor-electronics.co.uk) under number **044050-1** (select month of publication). It does not need to be installed — double clicking the filename *IIRTool.exe* is sufficient to launch the program. This program can simulate up to 10 different IIR filters. As an additional bonus, it is possible to cascade multiple filters in order to examine the total frequency characteristic.

Initially, after starting the program, all filters are set as all-pass and without delay. At the top left you can see that filter1 is selected. The coefficients that are shown on the screen belong to this filter. To enter your own coefficients for this filter you only need to click the desired coefficient after which you can type in the new value. For example, try changing  $a_1$  (the second value at the top of the column near  $a$ ) from 0 to 0.5. Immediately after this change you will note that the graph

of the frequency characteristic has changed.

At top left you can select another filter. Choose filter2. In the windows below it, the coefficients belonging to filter2 appear. This time change  $a_1$  to -0.5. There now appears a second frequency characteristic. This looks like the reverse of filter1. The colour of each filter curve can be changed by clicking the button *change color*. This makes it easier to distinguish the separate graphs.

In order to know what the total frequency characteristic will look like when a signal propagates through both these filters we can select filters 1 and 2 under the button *cascade*. Another curve will appear in the output window, which is the result of the two filters cascaded. The program is not only able to simulate filters but can also generate 3 different types of simple filters. These generators can be found under the menu *generate*. Here you can choose from bass-, mid- or treble-filters. With the bass and treble filter you can choose the cutoff frequency and the desired gain or attenuation. The bass filter provides gain or attenuation of frequen-

cies lower than the cutoff point. The treble filter does the same for frequencies higher than the cutoff point.

A practical example: first select filter number 3, then choose *generate* followed by *bass*. In the window that appears, give the parameter *frequency* a value of 100 and *gain* a value of 5. *Gain* is the location where we enter the gain or attenuation (in dB). Now click the button *OK*. The program will now quickly calculate the required coefficients. As a consequence the coefficients of filter 4 are changed and the result is shown in the graph. Generating a treble filter follows exactly the same method.

Finally, the program can also design a mid filter. This filter provides gain/attenuation of signals around a specific frequency. When entering the parameters you will find, besides *frequency* and *gain*, a third parameter, namely *Q*. This represents the quality factor of the filter. The higher the *Q* factor the narrower will be the frequency range of the filter. A *Q* factor between 0.6 and 2 is typical for audio applications.

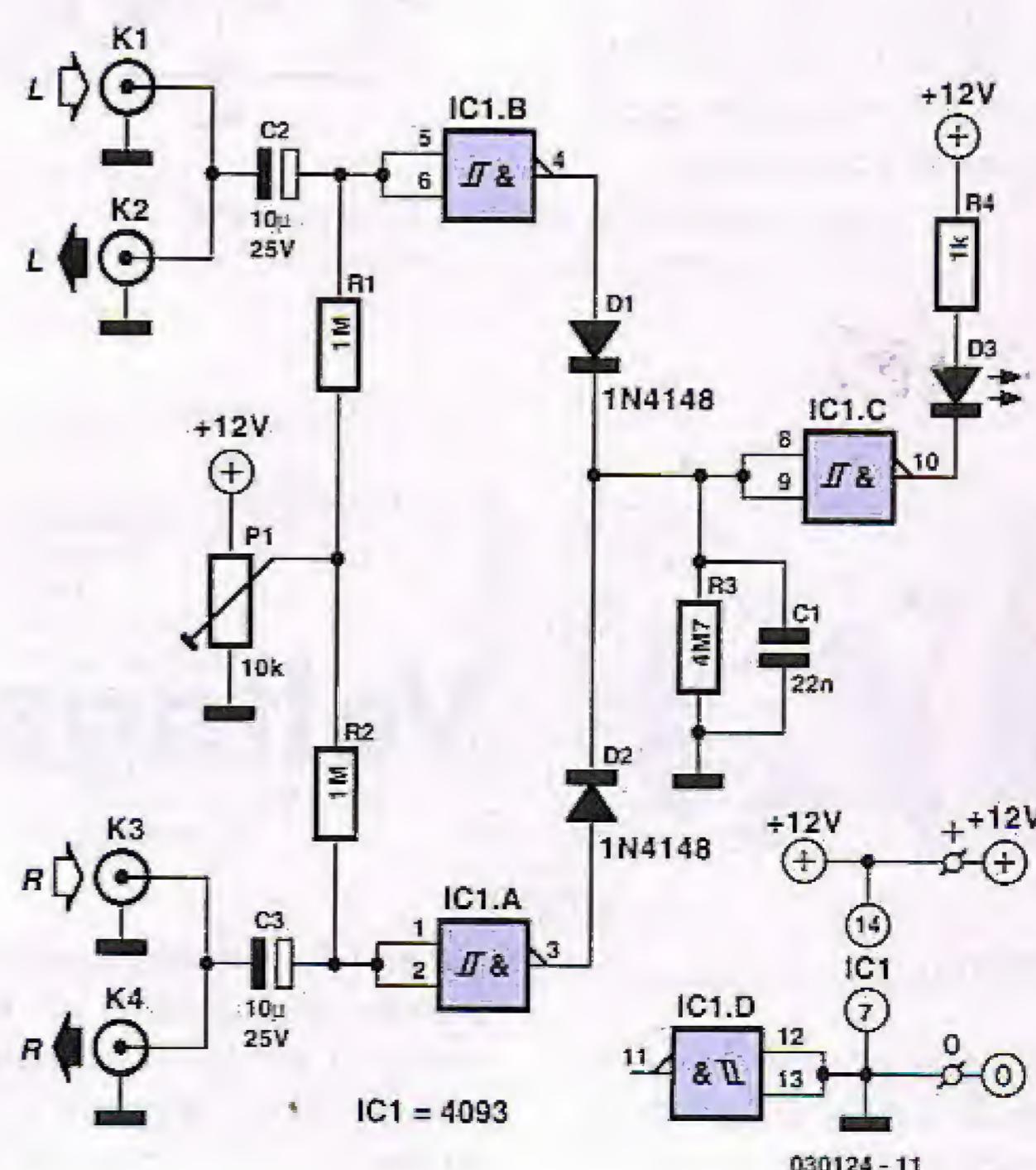
(044050-1)

## Simple Audio Peak Detector

Flemming Jensen

This audio peak detector allows a pair of stereo channels to be monitored on a single LED.

Identical circuitry is used in the left and right channels. Use is made of the switching levels of Schmitt trigger NAND gates inside the familiar 4093 IC. The threshold level for gate IC1.A (IC1.B) is set with the aid of preset P1, which supplies a high-impedance bias level via R2 (R1). When, owing to the instantaneous level of the audio signal superimposed on the bias voltage by C3 (C2), the dc level at pins 1 and 2 (5 and 6) of the Schmitt trigger gate drops below a certain level, the output of IC1.A (IC1.B) will go High. This level is copied to the input of IC1.C via D2 (D1) and due to the inverting action of IC1.C, LED D3 will light. Network R3-C1 provides some delay to enable very short audio peaks to be reliably indicated.



Initially turn the wiper of P1 to the +12 V extreme — LED D3 should remain out. Then apply 'line' level audio to K1 and K3, preferably music with lots of peaks

(for example, drum 'n bass). Carefully adjust P1 until the peaks in the music are indicated by D3.

The circuit has double RCA connectors for

the left and right channels to obviate the use of those rare and expensive audio splitter ('Y') cables.

(030124-1)

# 019

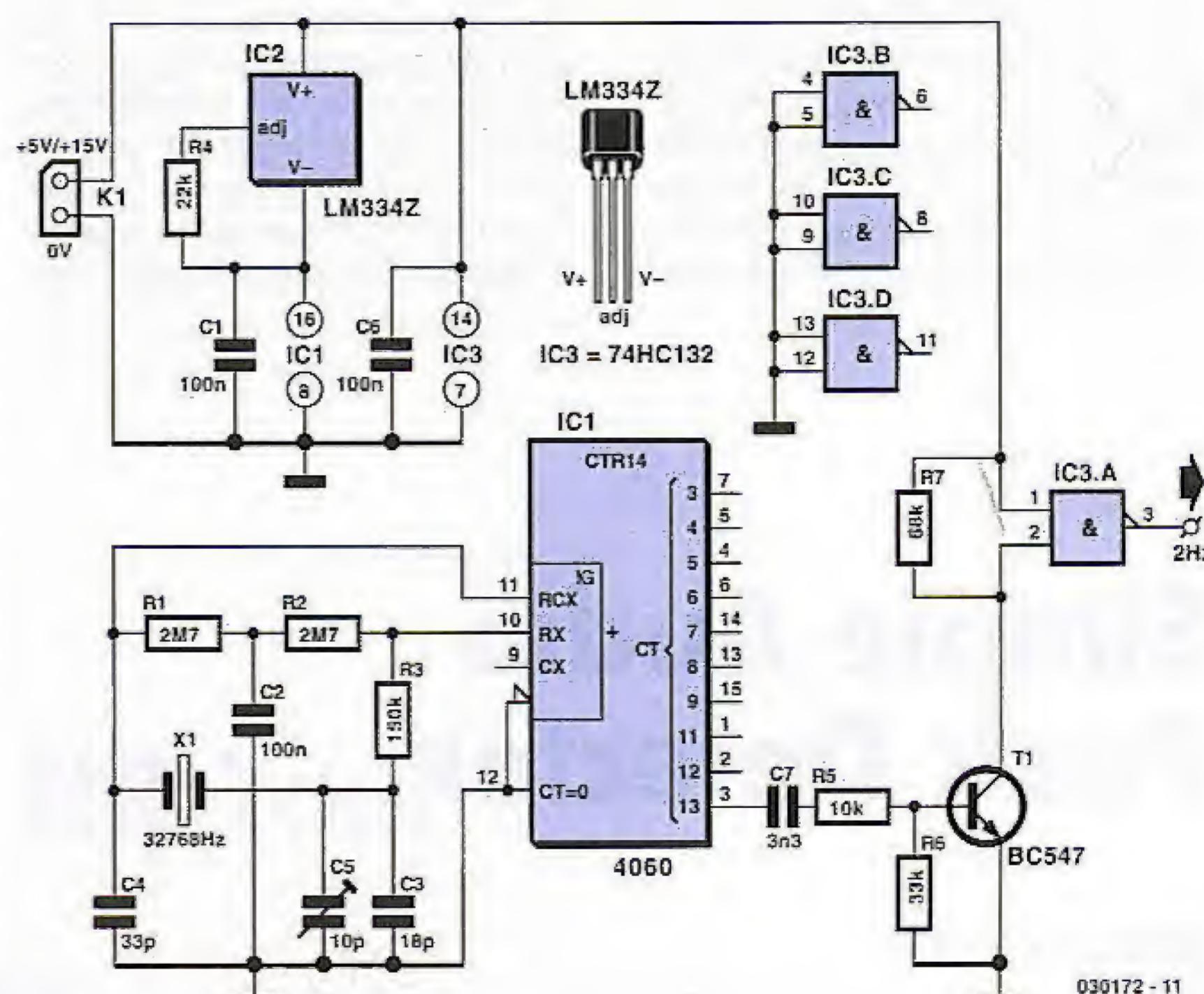
## Thrifty 2-Hz Clock

P.C. Hogenkamp

CMOS circuits are known for their low current consumption. This is particularly important for battery-powered circuits. Unfortunately, oscillators often require quite a bit of current. We therefore propose this oscillator circuit that has a very low current consumption (about 3  $\mu$ A). The circuit is powered from a type LM334Z current source. The current has been set with R4 to about 3  $\mu$ A. This is sufficient to power IC1 and the oscillator circuit around X1. The oscillator generates, with the aid of a cheap watch crystal and a few surrounding parts, a signal that is subsequently applied to the divider in the 4060 and results in a frequency of 2 Hz at pin 3 (output Q13).

The level of the output pulses is a lot lower than the nominal 5-V power supply voltage (IC1 is after all powered from a current source with very low current). That is why the signal on pin 3 of IC1 is amplified and inverted by T1. IC3a finally turns it into a proper square wave with acceptably steep edges.

(030172-1)



030172 - 11

# 020

## Voltage Monitor

Paul Goosens

It is often necessary to monitor the power supply voltage in a piece of equipment. When the device takes its power from a

battery, the input voltage can change and provide an indication of how much energy is left. Even a device powered from the mains can benefit from keeping an eye on the (various) power supply volt-

ages in the circuit and take the necessary steps in the event of a fault condition. If a slightly intelligent reaction is required for this situation, it is obvious to do this with a microcontroller. This requires the

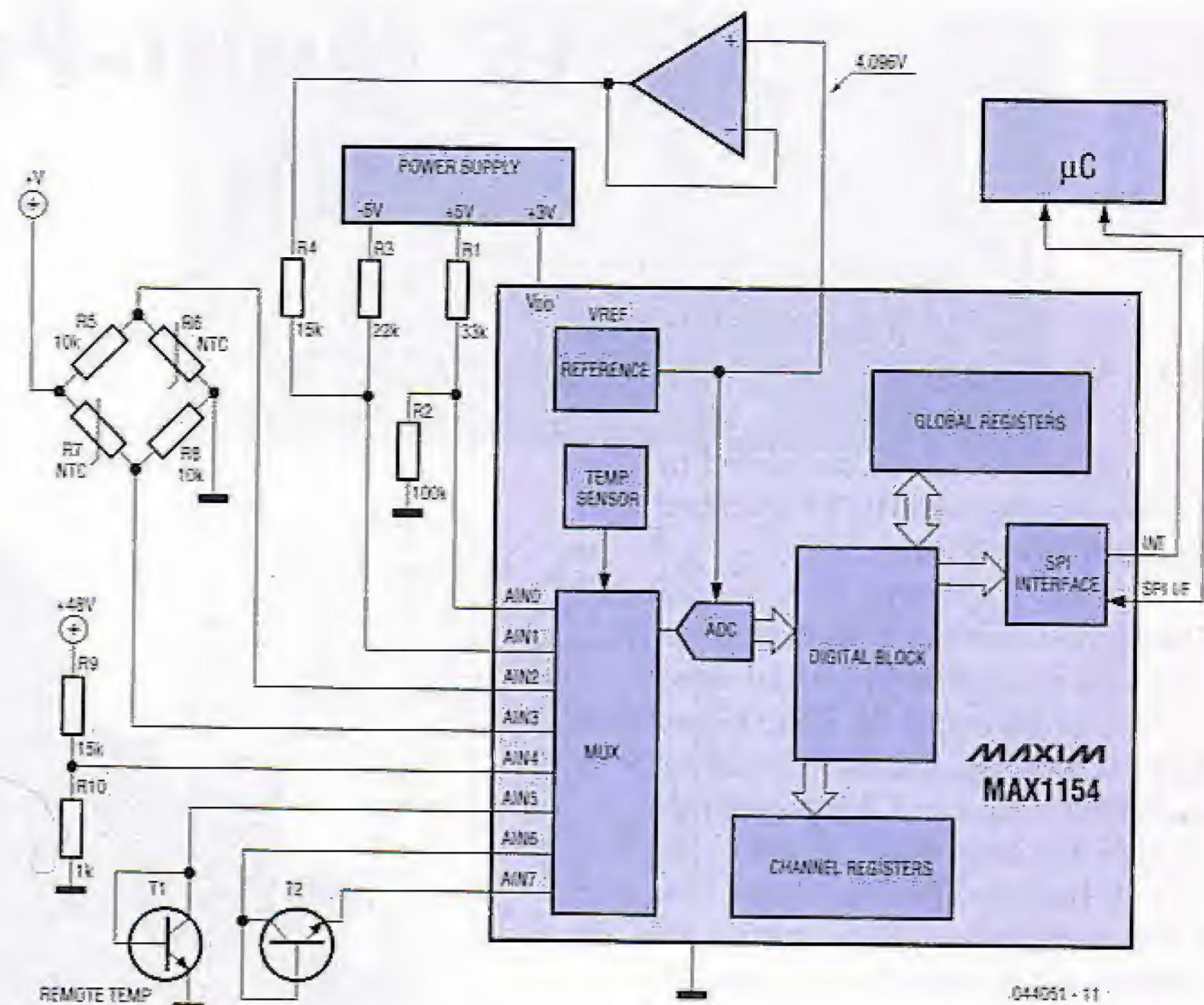
microcontroller to periodically measure the voltages with one or more A/D converters and decide whether the values are correct or whether something is the matter.

This naturally costs processor time and makes the firmware a little more complicated. This can become a problem, particularly when other functions have to be carried out on a regular basis as well.

Fortunately, chip manufacturer Maxim has a number of ICs in its line-up specifically for this purpose. These ICs all have as task to monitor a number of voltages and when these do not conform to certain requirements the IC generates an interrupt, which indicates to the microcontroller that something has gone wrong.

The MAX1153 and MAX1154 are provided with a 10-bit ADC, while the MAX1253 and MAX1254 are provided with a 12-bit ADC. All these ICs are capable of monitoring 8 external voltages and 2 internal voltages. These 8 external voltages can also be programmed for temperature sensors, where an external diode can be used as a simple and cheap sensor.

For each channel, a maximum and minimum voltage or temperature can be specified. As soon as the input voltage or temperature falls outside this range the interrupt output goes low. If desired, a glitch



044051-11

suppressor can be individually configured for each channel. A recursive averaging filter is also available and it is even possible to specify how many successive samples have to be outside the range before the interrupt is generated. The sample-rate of the ADC is also adjustable, to a maxi-

mum of 90 ksamples/s.

The SPI bus serves as interface to the controller and requires only four signals to communicate. For more information you can visit the Maxim website:

[www.maxim-ic.com](http://www.maxim-ic.com)

(044051-1)

## On-line Conversions

Luc Lemmens

From time to time you may come across a unit of measure that's completely unfamiliar. It also happens that the name sounds vaguely familiar, but you just can't remember the fine points. Although the Internet probably contains numerous sites that can help out, the most comprehensive one is probably

[www.onlineconversion.com](http://www.onlineconversion.com).

Here you can convert physics quantities such as, for example, lengths, velocity and forces. There are also conversion tools for currencies, clothing sizes and terminology used in cookbooks. Although the title of this article may imply otherwise, some parts can be downloaded and used off-line.

(044052-1)

Welcome to OnlineConversion.com  
Electric Current Conversions

Convert what quantity?

From:

abampere  
ampere  
biot  
centiampere  
coulomb/second  
deciampere  
dekaampere  
electromagnetic unit of current  
electrostatic unit of current  
franklin/second

To:

abampere  
ampere  
biot  
centiampere  
coulomb/second  
deciampere  
dekaampere  
electromagnetic unit of current  
electrostatic unit of current  
franklin/second

Convert

Result (rounded to 7 decimal places):

Info: Amp is the most common symbol for ampere. Amps is ampere, millamps is millampere, kiloamps is kiloampere; etc.

Peter Verhoosel

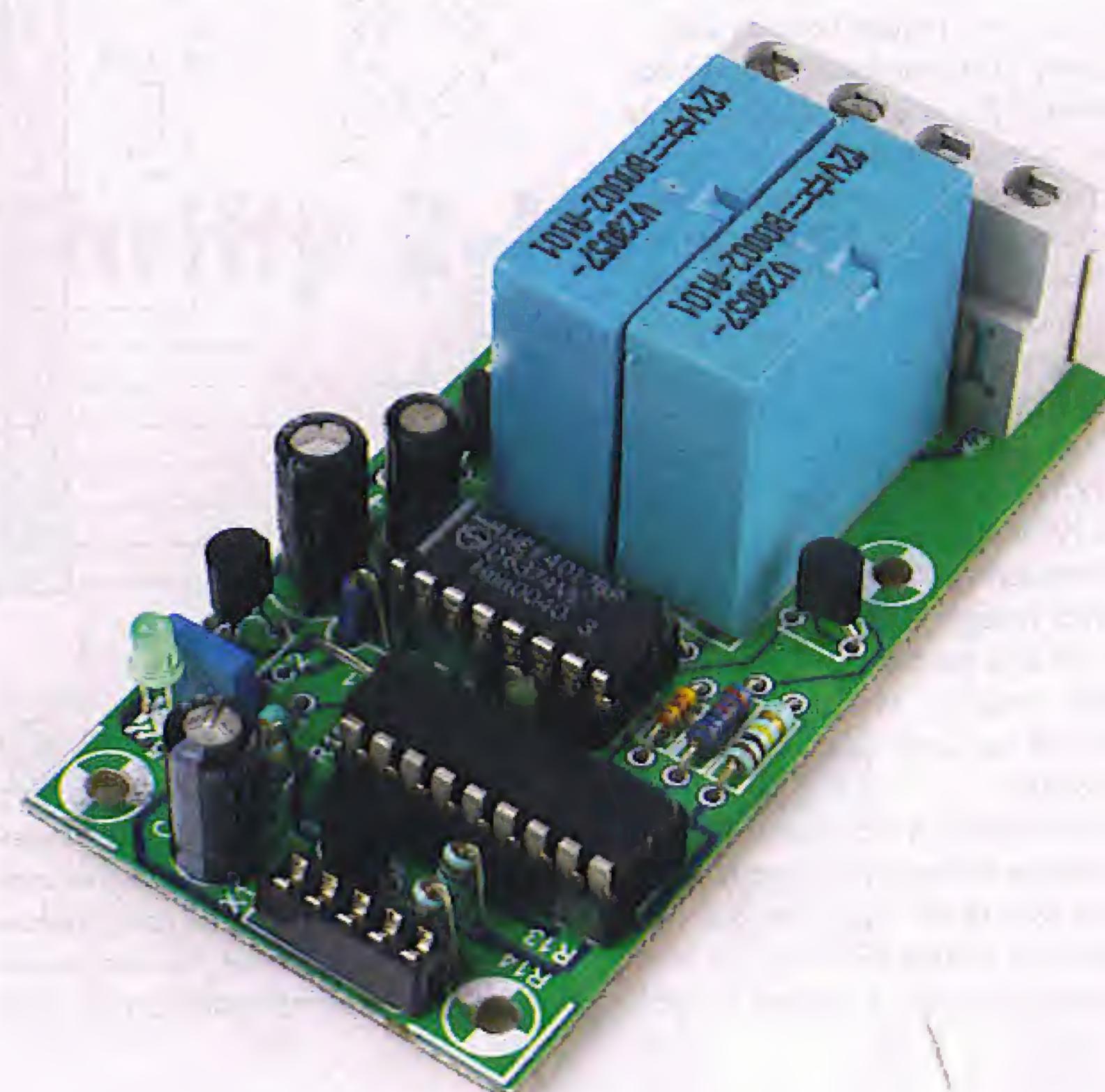
This multi-position switch is operated by the IR transmitter with HT12R described elsewhere in the issue.

The signal transmitted by the transmitter enters the circuit through infrared detector IC4. At the output the demodulated signal is available, that via R2 and T1 is routed to the input of IC1 (decoder type HT12D). Like the encoder IC, this IC has already been described in Elektor Electronics on multiple occasions and we will therefore not describe it again here. On the PCB the address lines of IC1 are by default connected with a thin trace to ground. The default address is therefore zero. By cutting the trace with a sharp knife the corresponding address input can be made logic high.

This change of address is only necessary if multiple transmitters are active in the same house.

When the programmed address code corresponds with the address code of the IR transmitter, pin 17 of IC1 will be high for as long as the transmitted signal is available. LED D4 will light up.

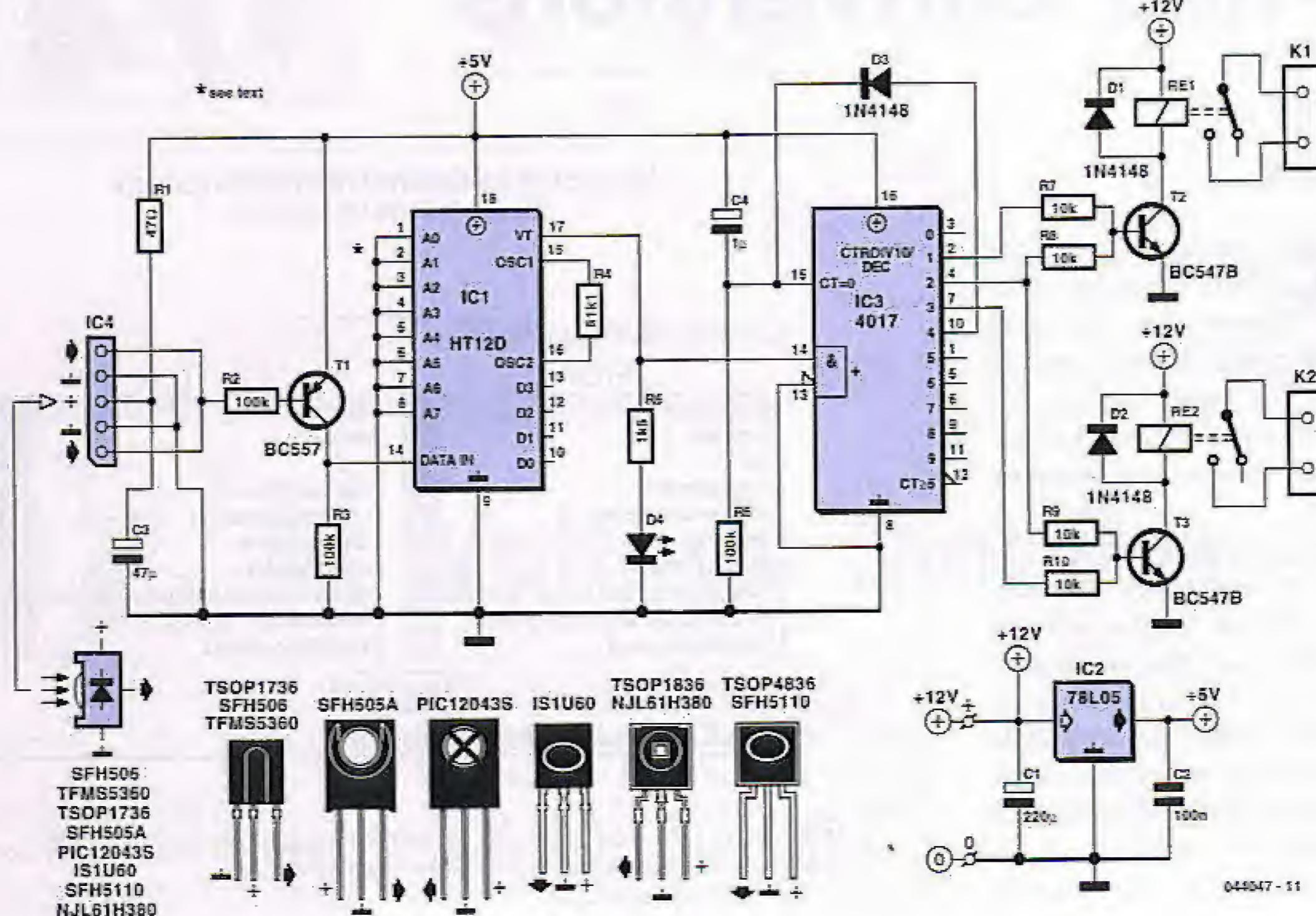
This pulse is presented to the clock input of IC3, a decade counter. After each pulse the decade counter will make the



next output high and the previous output will go low again.

When the power supply is switched on, C4 and R6 ensure that the IC is reset; the

first output is high and all the others are low. This is the reason that relays are connected only from the second output onwards.



## COMPONENTS LIST

### Resistors:

R1 = 47Ω  
 R2,R3,R6 = 100kΩ  
 R4 = 51kΩ  
 R5 = 1kΩ5  
 R7-10 = 10kΩ

### Capacitors:

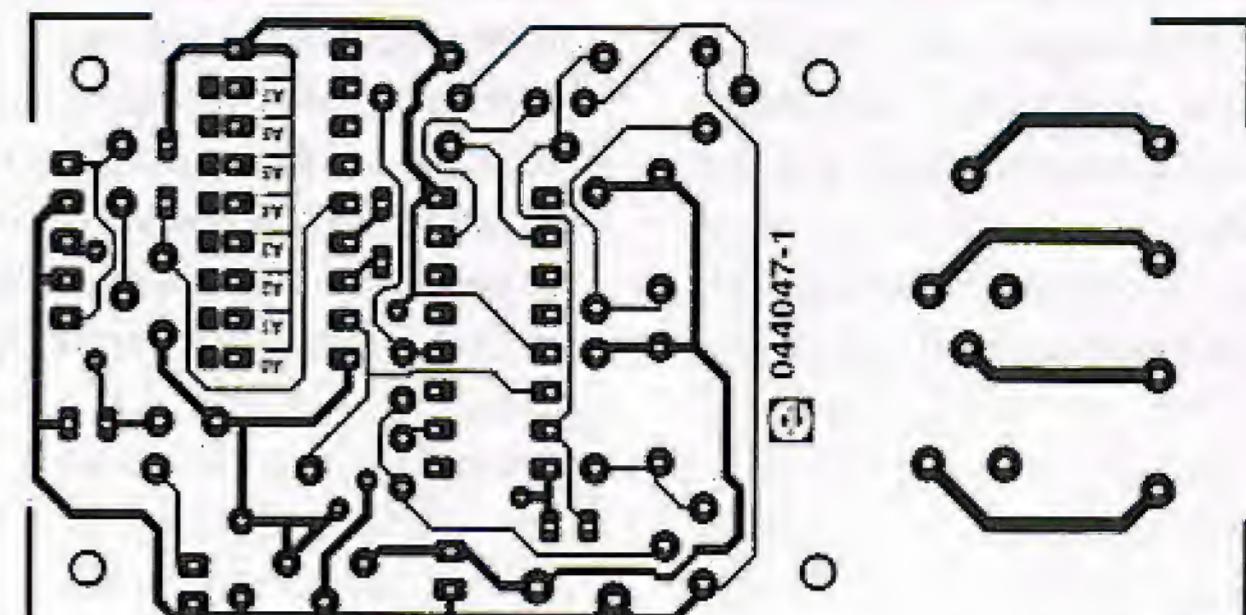
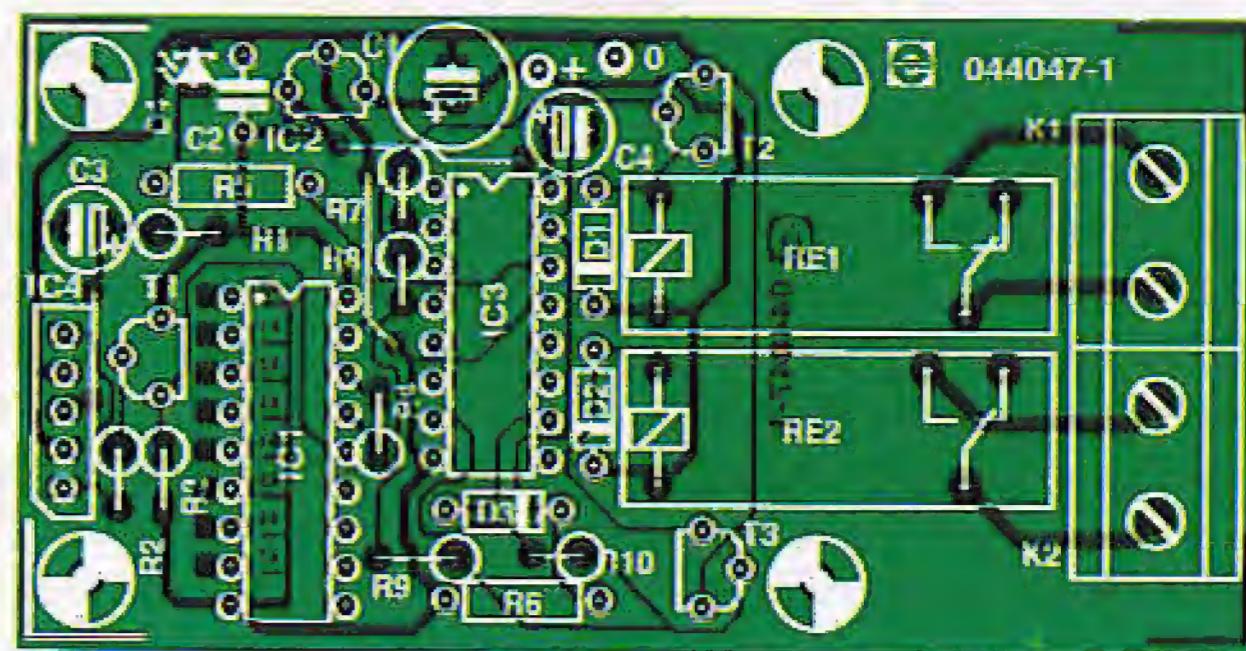
C1 = 220μF 16V radial  
 C2 = 100nF  
 C3 = 47μF 10V radial  
 C4 = 1μF 10V radial

### Semiconductors:

D1,D2,D3 = 1N4148  
 D4 = LED, red, high-efficiency  
 T1 = BC557  
 T2,T2 = BC547B  
 IC1 = HT12D (Holtek)  
 IC2 = 78L05  
 IC3 = 4017  
 IC4 = SFH506-40 or equivalent

### Miscellaneous:

Re1,Re2 = 12-V relay, e.g., Siemens V23057-B0002-A101  
 K1,K2 = 2-way PCB terminal block, lead pitch 7.5mm  
 PCB, available from The PCBShop



After the first pulse is transmitted, Re1 will be switched on via R7 and T1. The next pulse causes both Re1 and Re2 to be switched on. After the next pulse only Re2 will be on.

The reset-input of the decade counter is connected via D3 to output Q4. This causes the switch to return to the rest position after the next pulse.

(044047-1)

## LM4906 Boomer® Audio Power Amp

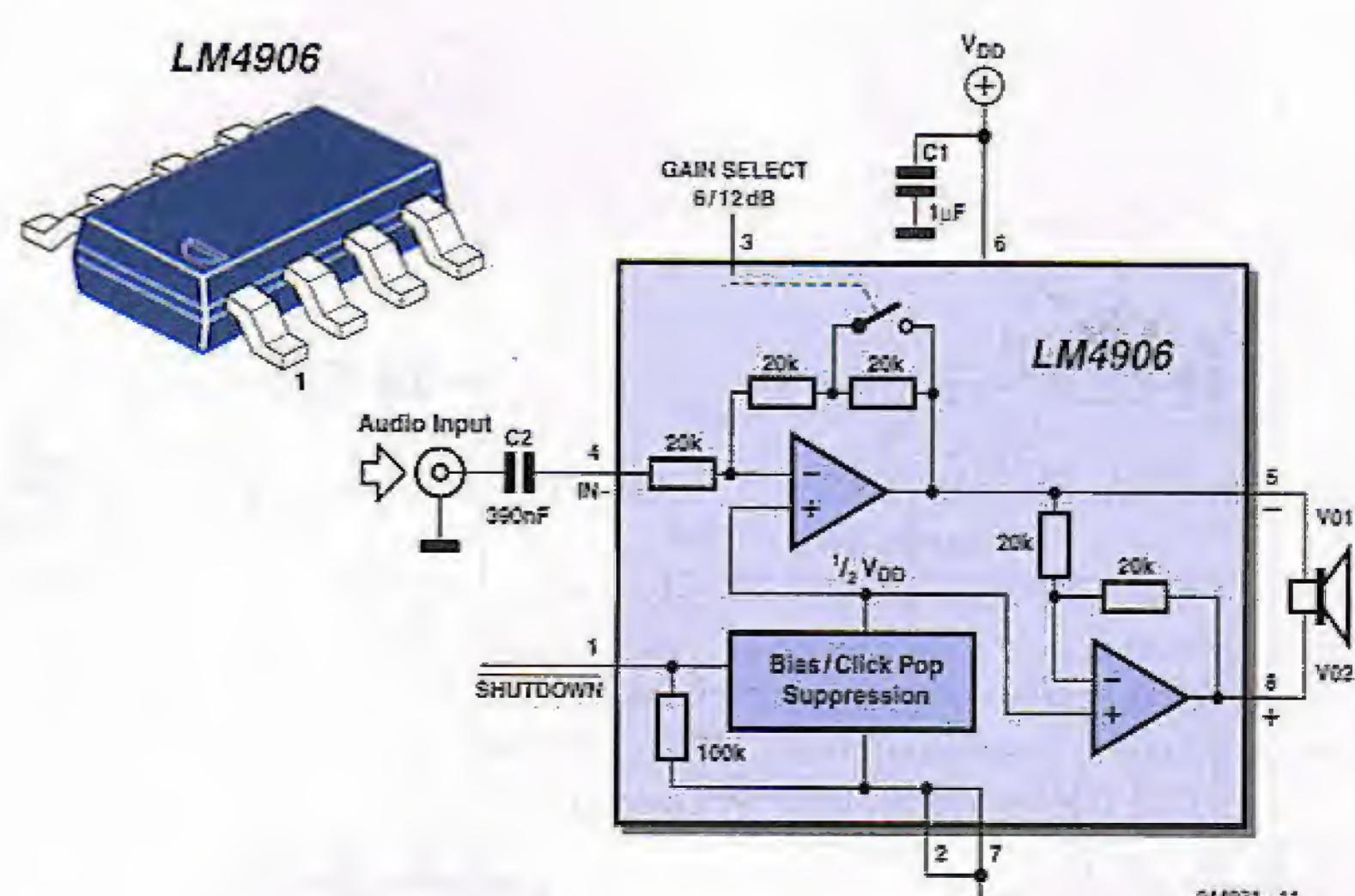
0/23

Source:  
National Semiconductor

The well-known LM386 is an excellent choice for many designs requiring a small audio power amplifier (1-watt) in a single chip. However, the LM386 requires quite a few external parts including some electrolytic capacitors, which unfortunately add volume and cost to the circuit.

National Semiconductor recently introduced its Boomer® audio integrated circuits which were designed specifically to provide high quality audio while requiring a minimum amount of external components (in surface mount packaging only).

The LM4906 is capable of delivering 1 watt of continuous average power to an 8-ohm load with less than 1% distortion (THD+N) from a +5 V power supply. The chip happily works with an external PSRR



(Power Supply Rejection Ratio) bypass capacitor of just 1 μF minimum. In addition, no output coupling capacitors or bootstrap capacitors are required which

makes the LM4906 ideally suited for cell-phone and other low voltage portable applications. The LM4906 features a low-power con-

sumption shutdown mode (the part is enabled by pulling the SD pin high). Additionally, an internal thermal shutdown protection mechanism is provided. The LM4906 also has an internal selectable gain of either 6 dB or 12 dB.

A bridge amplifier design has a few distinct advantages over the single-ended configuration, as it provides differential drive to the load, thus doubling output swing for a specified supply voltage. Four times the output power is possible as compared to a single-ended amplifier under the same conditions (particularly when considering the low supply voltage of 5 to 6 volts).

When pushed for output power, the small SMD case has to be assisted in keeping

a cool head. By adding copper foil, the thermal resistance of the application can be reduced from the free air value, resulting in higher PDMAX values without thermal shutdown protection circuitry being activated. Additional copper foil can be added to any of the leads connected to the LM4906. It is especially effective when connected to VDD, GND, and the output pins.

A bridge configuration, such as the one used in LM4906, also creates a second advantage over single-ended amplifiers. Since the differential outputs, Vo1 and Vo2, are biased at half-supply, no net DC voltage exists across the load. This eliminates the need for an output coupling capacitor which is required in a single supply, single-

ended amplifier configuration. Large input capacitors are both expensive and space hungry for portable designs. Clearly, a certain sized capacitor is needed to couple in low frequencies without severe attenuation. But in many cases the speakers used in portable systems, whether internal or external, have little ability to reproduce signals below 100 Hz to 150 Hz. Thus, using a large input capacitor may not increase actual system performance. Also, by minimizing the capacitor size based on necessary low frequency response, turn-on pops can be minimized.

Further information from:  
[www.national.com](http://www.national.com)

(044031-1)

# 024

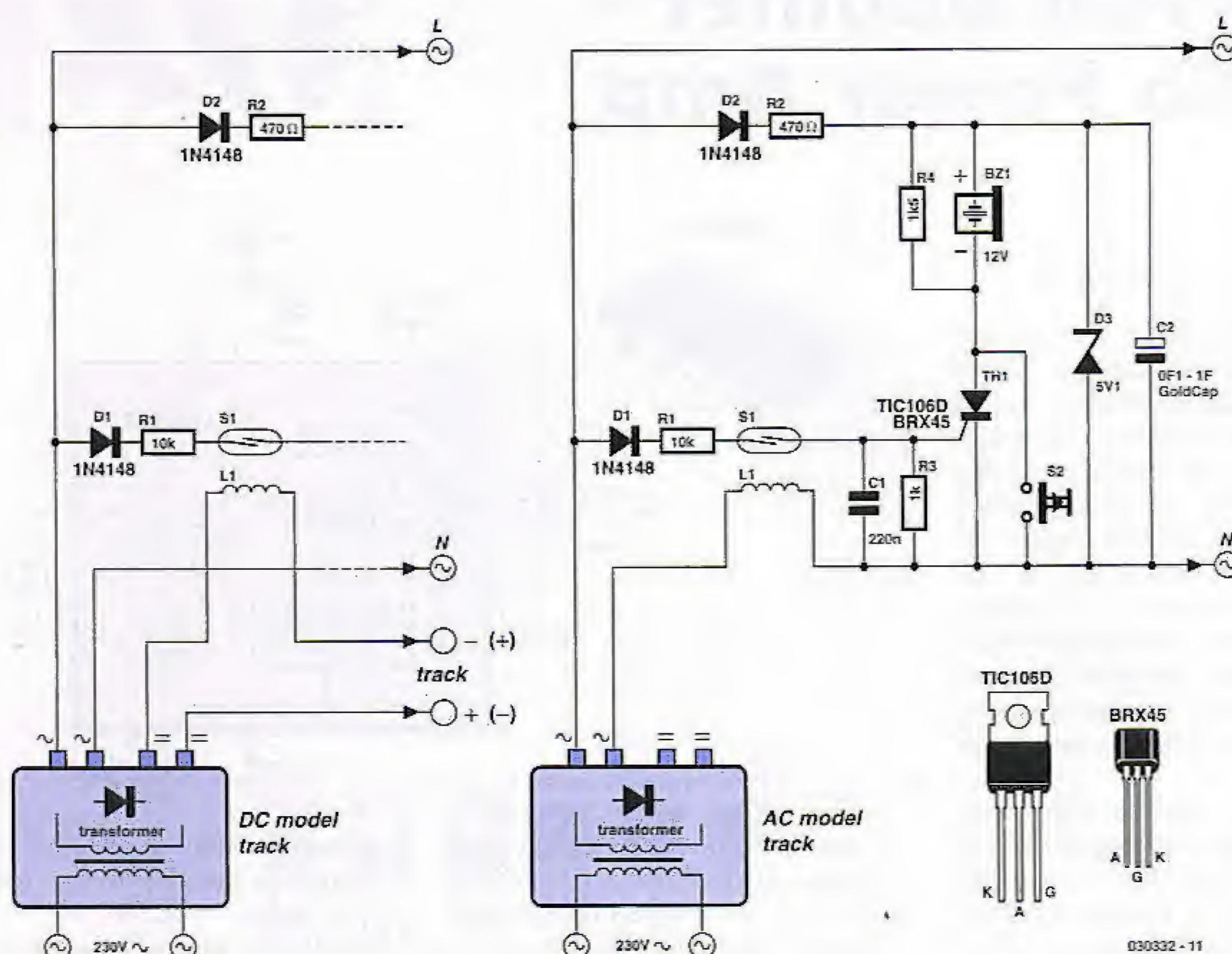
## Model Railway Short-Circuit Beeper

R. Edlinger

Short circuits in the tracks, points or wiring are almost inevitable when build-

ing or operating a model railway. Although transformers for model systems must be protected against short circuits by built-in bimetallic switches, the response

time of such switches is so long that is not possible to immediately localise a short that occurs while the trains are running, for example. Furthermore, bimetallic pro-



tection switches do not always work properly when the voltage applied to the track circuit is relatively low.

The rapid-acting acoustic short-circuit detector described here eliminates these problems. However, it requires its own power source, which is implemented here in the form of a GoldCap storage capacitor with a capacity of 0.1 to 1 F.

A commonly available reed switch (filled with an inert gas) is used for the current sensor, but in this case it is actuated by a solenoid instead of a permanent magnet. An adequate coil is provided by several turns of 0.8–1 mm enameled copper wire wound around a drill bit or yarn spool and then slipped over the glass tube of the reed switch. This technique generates only a negligible voltage drop. The actuation sensitivity of the switch (expressed in ampere-turns or A·t) determines the number of turns required for the coil. For instance, if you select a type rated at 20–40 A·t and assume a maximum allowable operating current of 6 A,

seven turns ( $40 \div 6 = 6.67$ ) will be sufficient. As a rule, the optimum number of windings must be determined empirically, due to a lack of specification data.

As you can see from the circuit diagram, the short-circuit detector is equally suitable for AC and DC railways. With Märklin transformers (HO and I), the track and lighting circuits can be sensed together, since both circuits are powered from a single secondary winding.

Coil L1 is located in the common ground lead ('O' terminal), so the piezoelectric buzzer will sound if a short circuit is present in either of the two circuits. The (positive) trigger voltage is taken from the lighting circuit (L) via D1 and series resistor R1. Even though the current flowing through winding L1 is an AC or pulsating DC current, which causes the contact reeds to vibrate in synchronisation with the mains frequency, the buzzer will be activated because a brief positive pulse is all that is required to trigger thyristor Th1. The thyristor takes its anode voltage

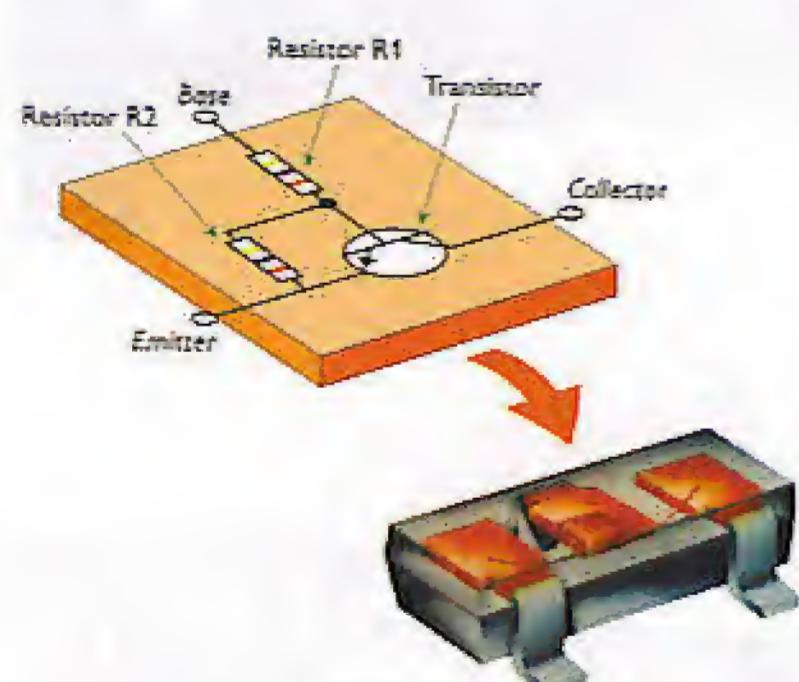
from the GoldCap storage capacitor (C2), which is charged via C2 and R2. The alarm can be manually switched off using switch S1, since although the thyristor will return to the blocking state after C2 has been discharged if a short circuit is present the lighting circuit, this will not happen if there is a short circuit in the track circuit. C1 eliminates any noise pulses that may be generated.

As a continuous tone does not attract as much attention as an intermittent beep, an intermittent piezoelectric generator is preferable. As almost no current flows during the intervals between beeps and the hold current through the thyristor must be kept above 3 mA, a resistor with a value of 1.5–1.8 kΩ is connected in parallel with the buzzer. This may also be necessary with certain types of continuous-tone buzzers if the operating current is less than 3 mA. The Zener diode must limit the operating voltage to 5.1 V, since the rated voltage of the GoldCap capacitor is 5.5 V.

(030332-1)

## Resistor-Equipped Transistors (RETs)

0425



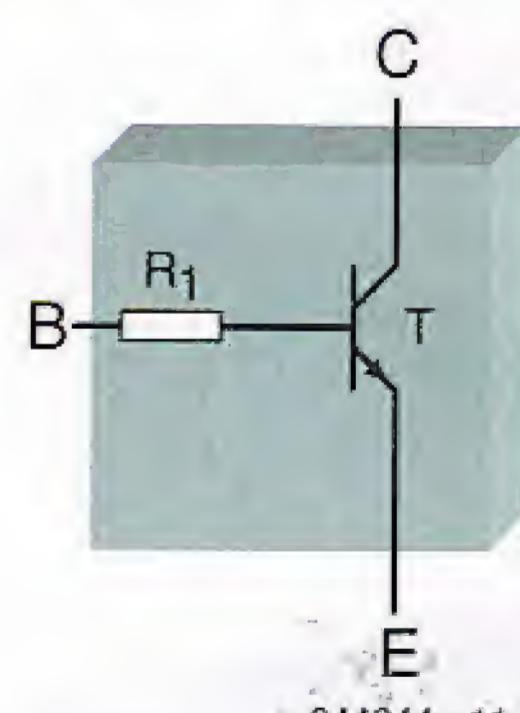
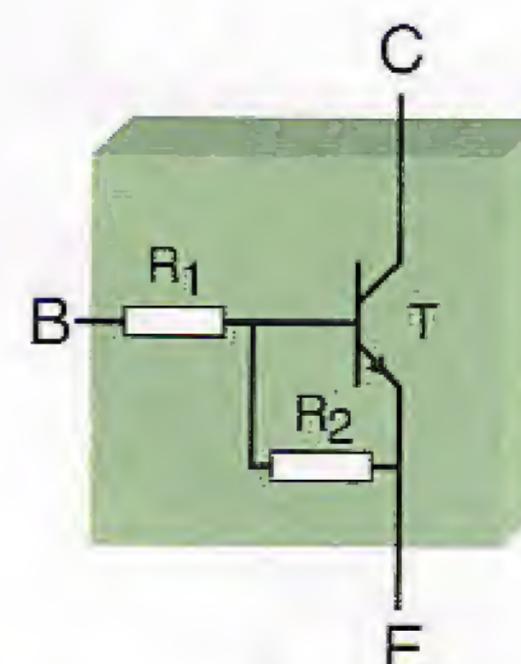
**Paul Goossens**

Developments in the electronics area (or is it an arena?) are never at a standstill. Whenever there is something substantially new to report it is almost always related to complex chips. However, Philips proves that new developments are possible even with what you thought were dead-standard components. For example, take the new range of transistors with the name 'RET' – meaning *Resistor Equipped Transistor*. The novelty with this new range of transistors is that they have a base resistor

included. Some versions also have a resistor from base to emitter.

These new transistors enable engineers to design even smaller devices because the space required on the PCB has been reduced as a consequence. An additional advantage is that the total component count is reduced.

The new transistors are available in both PNP and NPN versions. For the package, the designer can choose from a number of SMD packages as well as the familiar TO-92. The maximum power dissipation depends on the package and varies from



044044 - 11

150 mW to 500 mW for the single transistor chips.

There are also chips with two transistors, where each chip is provided with either one or two resistors. With these you can choose between a maximum dissipation of 300 mW or 600 mW.

A complete overview of the available RETs can be found on the Internet at: <http://www.semiconductors.com/acrobat/literature/9397/75012514.pdf>.

(044044-1)

source: Philips

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# Low-Drop Constant Current Source

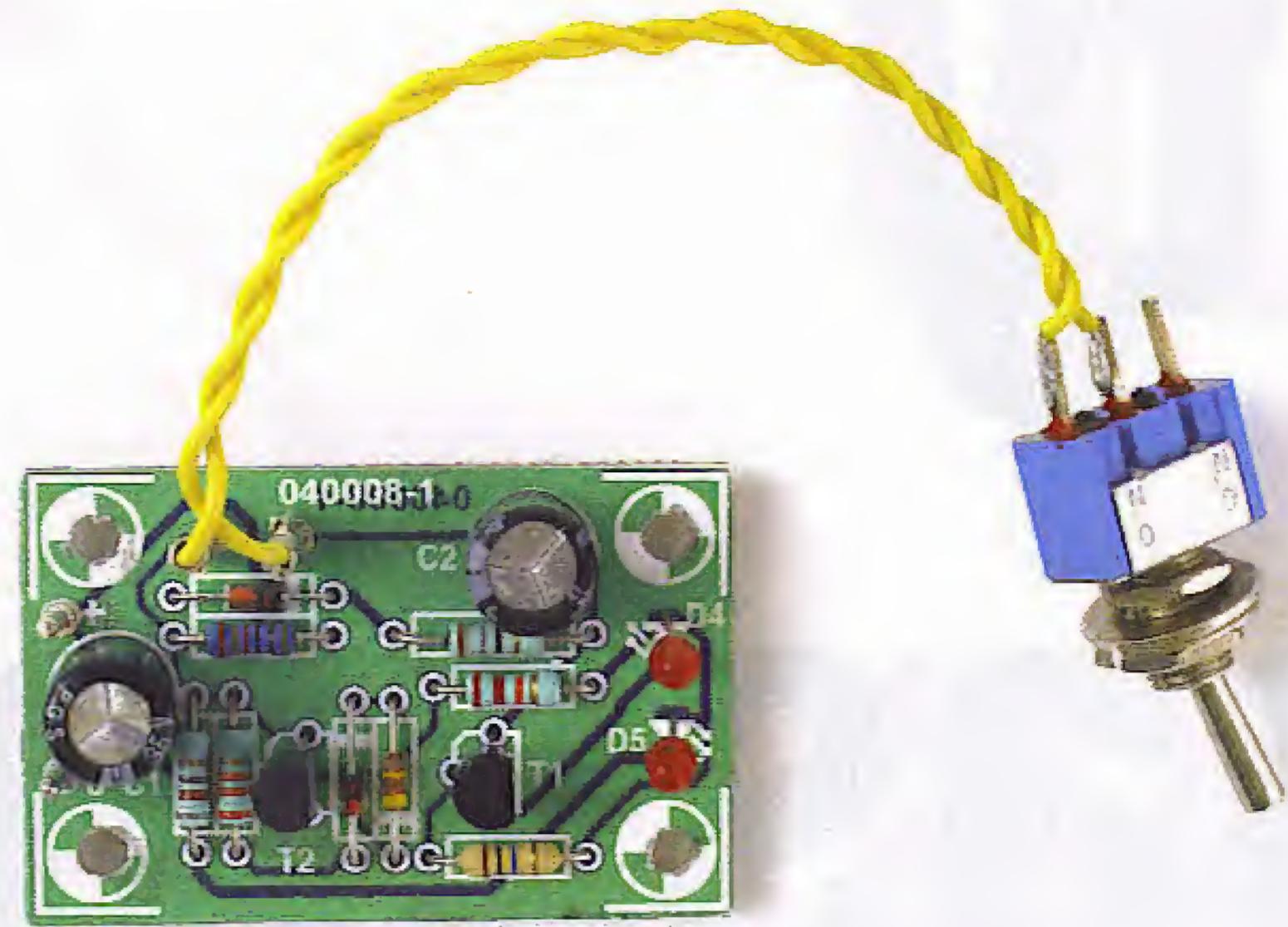
## for Ultrabright LEDs

Olaf König

Ultrabright LEDs are becoming increasingly attractive for use in lighting and warning-signal applications. LEDs must be operated at a constant current to ensure that they continue to emit light at the same brightness. The usual approach is to use a series resistor, but in order to prevent the non-linear voltage/current characteristic, the NTC property of the LED and variations in the supply voltage from affecting brightness, we'd like to have something better.

The circuit described here is a low-drop constant current source for ultrabright LEDs with blinking capability, for use in headlights, taillights, dog blinkers, light chains, car alarms and the like. It provides a constant current of 20 mA with a supply voltage of 4.5–30 V, or 50 mA with a 4.5–12 V supply. The voltage drop of the circuit is only 0.6 V, so practically the entire supply voltage can be used for the LEDs.

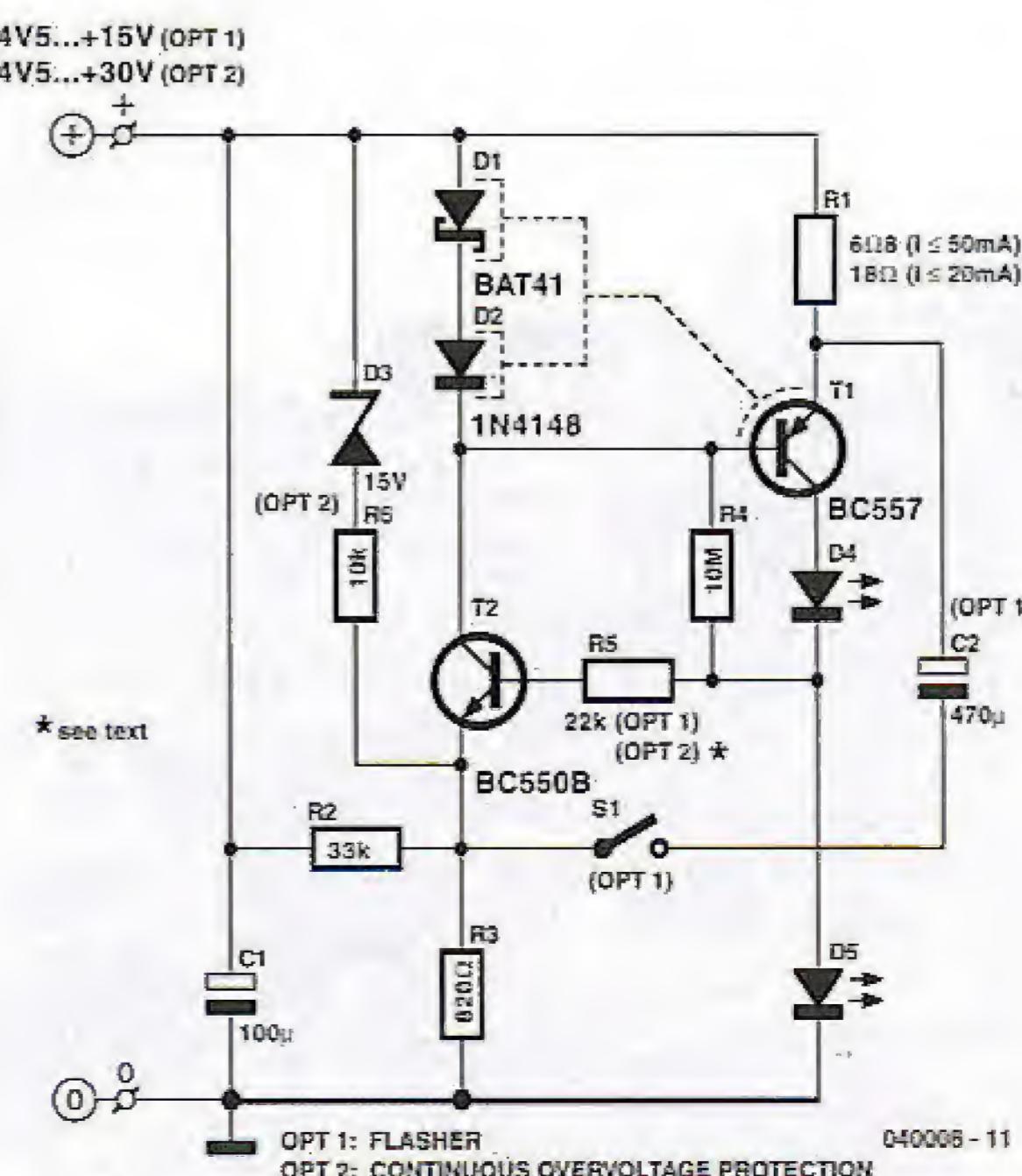
When the supply voltage is switched on, D5 generates a start-up voltage if the circuit is exposed to light (an LED can generate a photoelectric current). To enable the constant-current source to also reliably start up in the dark, R4 provides an initial base current to T1 and T2. In any case, both transistors initially only pass a small amount of current. But since each transistor provides the base current for the other one, the current rises to its setpoint value. The setpoint is stably maintained as follows. The voltage across D5, less the base-emitter voltage of T2, is also present across R3 (R5 has no effect at the beginning). A stabilised current thus flows through R3. Most of the constant current flowing through T2 comes from D1 and D2, with only a secondary contribution from the base current of T1. The voltage across D1 and D2 is also stable, due to the stabilised current. This voltage, less the base-emitter voltage of T1, is present across R1, where it causes a constant current to flow through T1 and D5 (and D4 if present). This closes the loop. The circuit thus consists of two constant-current sources

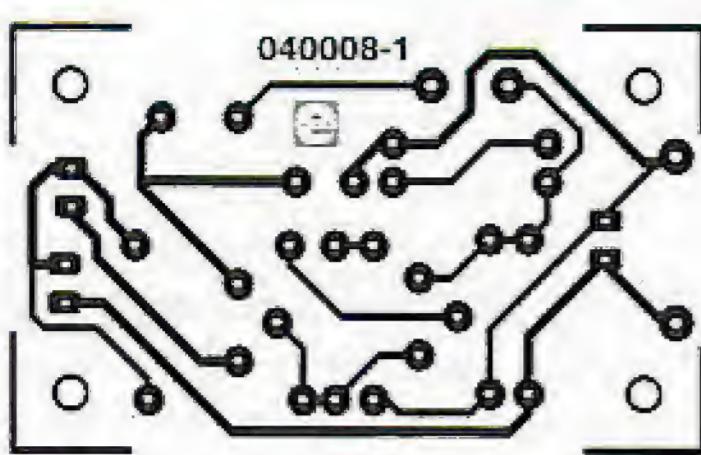
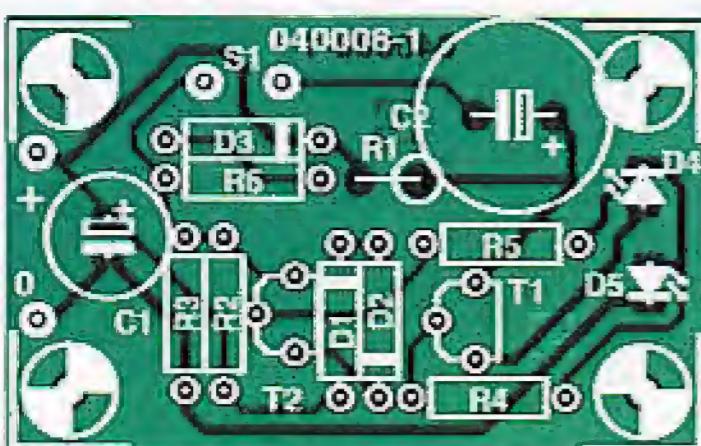


that stabilise each other. That's the basic principle.

R2 increases the voltage across R3. This causes the current to be reduced proportional to the supply voltage, which further stabilises the current. R2 is thus configured such that the current actually decreases slightly as the battery voltage increases. This causes T1 to be driven into full saturation at low voltages. D2 is intended to compensate for the

base-emitter voltage of T1, while Schottky diode D1 provides the 'miserly' voltage drop across R1. D1 and D2 are thermally coupled to T1. As a result, with increasing temperature the current is more likely to decrease than increase. LED D4 is included in the circuit to prevent T2 from having to go into saturation at low operating voltages. That wrings out an extra 0.2 V or so. In this way, the battery is mercilessly sucked dry when is





becomes weak. It's totally defenceless. However, rechargeable batteries should never be deep-discharged! Overvoltage protection should be included if the circuit is intended to be used for general experimentation or with LED chains. In case of overvoltage, D3 starts conducting and takes current away from T2 (which is essentially what R2 does as well). To prevent overheating of T1, particularly with a current of 50 mA, the current is sharply reduced for voltages greater than approximately 15 V. The upper voltage limit is then practically determined solely by the maximum collector voltage ( $U_{CE}$ ) ratings of the two transistors.

An LED chain can best be inserted in series with the supply voltage, in order to avoid making any changes to the circuit. Naturally, at least D5 must still remain in the circuit.

R5 and C2 form part of the blinking circuit. R5 and C1 smooth out large current spikes and RF oscillations during blinking operation. Low-impedance feedback is provided by C2. The resulting pulses are long enough to be clearly visible and short enough to use as little energy as

## COMPONENTS LIST

### Resistors:

R1 = 6Ω8 or 18Ω (see text)  
R2 = 33kΩ  
R3 = 820Ω  
R4 = 10MΩ  
R5 = 22kΩ or 0 Ω (see text)  
R6 = 10kΩ

### Capacitors:

C1 = 100μF 40V radial

C2 = 470μF 40V radial

### Semiconductors:

D1,D2 = BAT41 or similar Schottky diode with  $I_F > 80\text{mA}$   
D3 = zener diode 15V, 0.5W  
D4,D5 = LED (see text)  
T1 = BC557B  
T2 = BC550B

### Miscellaneous:

S1 = switch (see text)  
PCB, order code 040008-1 from the PCBshop

possible. The duty cycle is only 10 %. However, at base voltages less than 5 V (with two LEDs fitted) it increases to 50 %, with an accompanying decrease in current. Below 4.6 V, shortly before the circuit 'runs dry', the pulse heads toward zero. The 10%-pulses achieve the rated pulse current level of 100 mA for 50-mA LEDs, and they have such steep edges that two blinkers connected to a single power source blink in unison if they are not decoupled by at least 1 Ω. The voltage fluctuations on C2 are so small (approximately 0.6 V) that hardly any energy is lost.

We have designed a small printed circuit board for the constant-current source, which could hardly be easier to build and does not require any comments. Diodes D1 and D2 are placed immediately next to T1 and thus adequately thermally coupled. For a maximum constant current of 50 mA, the value of R1 should be 6.8 Ω, while for 20 mA a value of 18 Ω should be used. Naturally, the value of R1 can be increased even more to reduce the value of the constant current any the desired level.

If T1 does not have the anticipated cur-

rent gain of 140, R3 should be reduced to 680 Ω. The current flowing through diodes D1 and D2 should be at least three times the base current of T1. Naturally, the base current flowing through T2 is not multiplied. The value of  $I_{R3}$  is thus  $4 \times I_{B1}$  (since  $I_{B2}$  can be neglected). As D5 determines the voltage across R3, we thus have the formula:

$$R3 \leq \beta T1 \times [(U_{D4} - 0.65 \text{ V}) / (4 \text{ k}_{\text{const}})]$$

The maximum permissible value of  $U_{D1}$  is 340 mV. From the author's experience, when setting the level of the constant current it helps to try several diodes for D2 with different tolerance values. In stubborn cases of excessively high current levels (or if you want to be on the safe side but don't want to or can't measure, adjust or whatever), you can simply connect two 1N4148s in parallel. This will cause the operating point to lie somewhat lower on the characteristic curve.

Another important tip for avoiding eye injury (retina damage): never look directly at an ultrabright LED, especially in the dark!

(040008-1)

## SATA

Karel Walraven

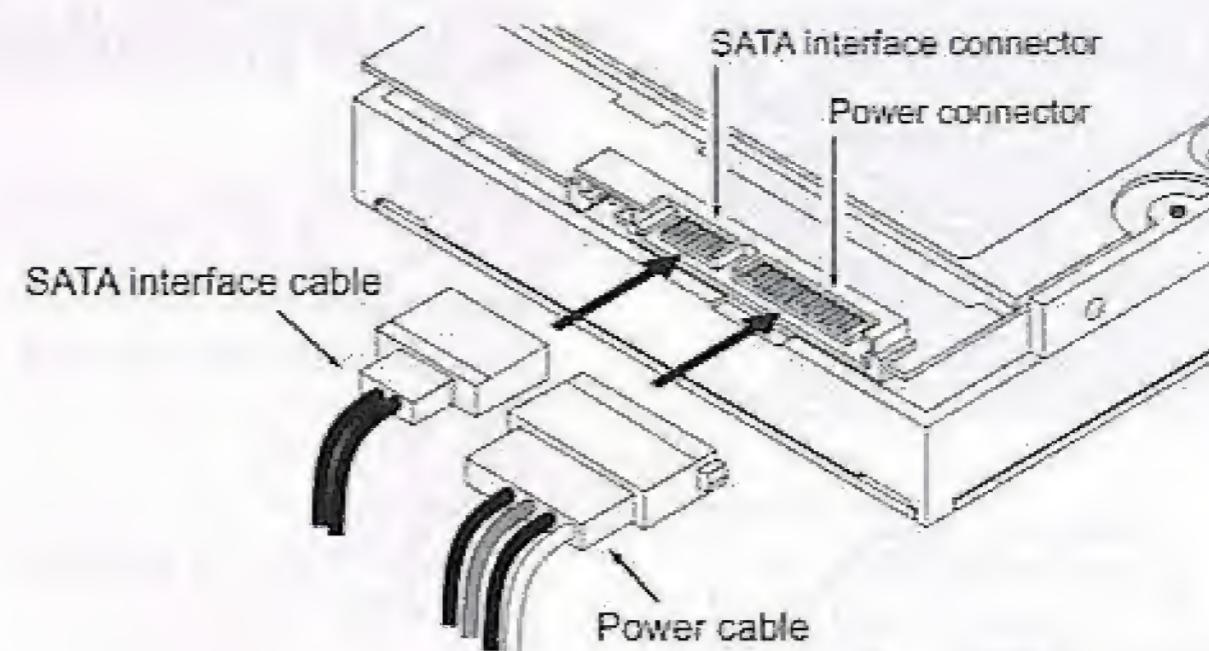
There is a new standard these days for connecting hard disks and DVD drives:

SATA. You may already have noticed that new PCs don't contain the wide 40- or 80-pin ribbon cables any more, but the hard disk is connected with a slender 7-

way cable. Even the corresponding power-supply connector is different with a SATA drive and now has 15 connections instead of 4. This is clearly illustrated

in the drawing: The *large* connector provides power and the *small* connector is the data connection. The power supply connector provides 12, 5 and 3.3 V and two ground connections.

SATA means Serial ATA. ATA is the connection standard that at present has been the most common for hard disks, CD and DVD drives. At the time of writing the ATA100 bus with a data transfer speed of 100 Mbyte/s is the most widespread. A number of manufacturers use the slightly faster ATA133 bus. That is pretty much the end of the line; it has not been possible for the industry to increase the speed even further using simple means. In order to increase the speed of the interface between motherboard and HDD, a serial connection was selected. At first glance this appears to be an perplexing choice! The parallel ATA bus operates with 16 bits simultaneously; the serial bus therefore has to be at least 16 times faster to obtain the same equivalent speed. That is why SATA operates at a clock speed of 1500 MHz and reaches a data transfer speed of 150 MByte/s; versions with 3 GHz and



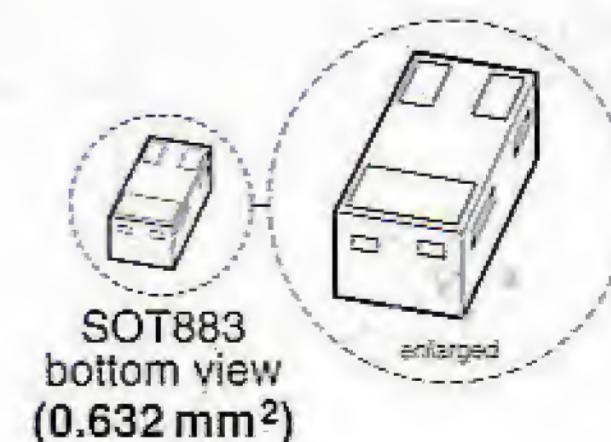
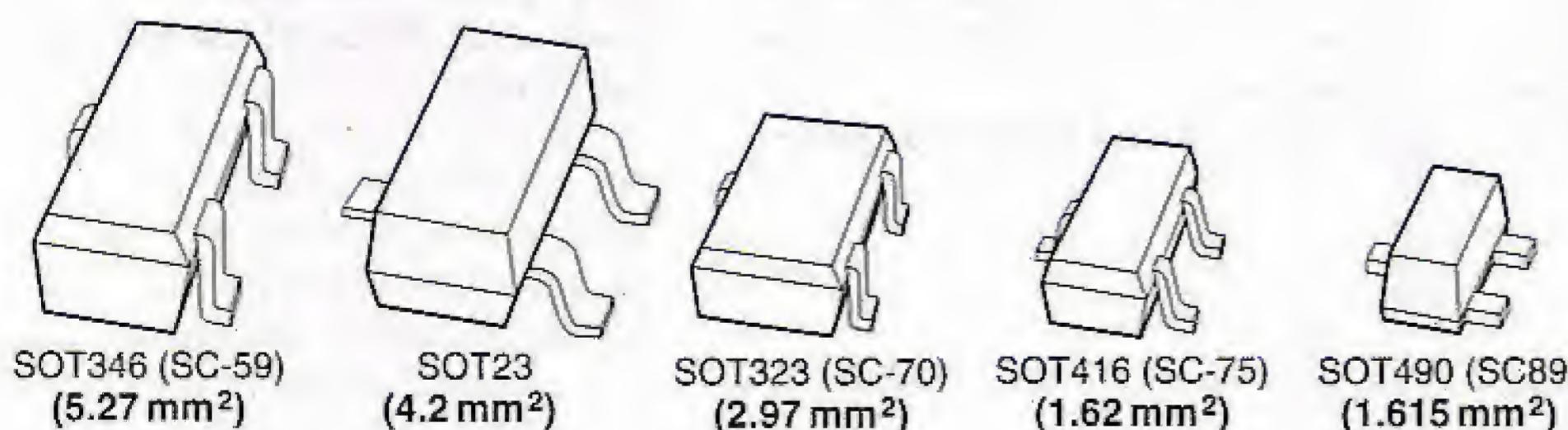
6 GHz clock speed are planned. The industry made this choice because, in the end, it is cheaper to have a solution with one data channel at very high speed than trying to increase the speed of all 33 signals in the ATA connection. The data connection has a balanced outgoing and a balanced return connection, plus three ground connections. The signal amplitude is not 5 volts any more, but only 0.25 volts. The symmetrical connection and the small signal amplitude together result in a fast, low interference and energy efficient connection. In addition, the cable is allowed to be much longer: 1 m instead of 45 cm with ATA.

Another big difference is that each device (HDD, DVD) has its own cable and connection to the motherboard. With the current ATA standard two devices can share the same cable. As a consequence various jumpers (master, slave) disappear and the interface can (in principle) always operate at maximum speed. Additionally, the contacts in the connectors are of different length, so that hot-plugging (connecting or disconnection without switching the power off) becomes possible. The expectation is that this interface will satisfy the requirements for the next ten years.

(044053-1)

**07/08**

## Modern SMD Packages



### Paul Goossens

Parts in SMD packages are becoming more and more frequent in DIY circuits. Sometimes they are used because of better performance, usually as a consequence of the shorter PCB traces between the various parts. The result of this is a lower self-inductance so the circuit exhibits better RF behaviour. Another reason components in an SMD

package are selected is simply because the equivalent parts in a 'through-hole' package are no longer being manufactured. All those different packages have naturally resulted in several new standards for packages. Here we show a number of common SMD packages with three terminals.

In particular, note the difference in dimensions for the various packages. Arguably a SOT346 package is a lot easier to sol-

der than a SOT490 package. It is obvious then, that a SOT883 package is going to be the most difficult to solder. Not only is the package extremely small, but in addition, the terminals are underneath. This means that it cannot be soldered with a soldering iron. To solder these, you would have to resort to using a hot plate, an iron or even better: an SMD oven.

(044045-1)

# **Stable Filament Supply**

Dr Alexander Voigt

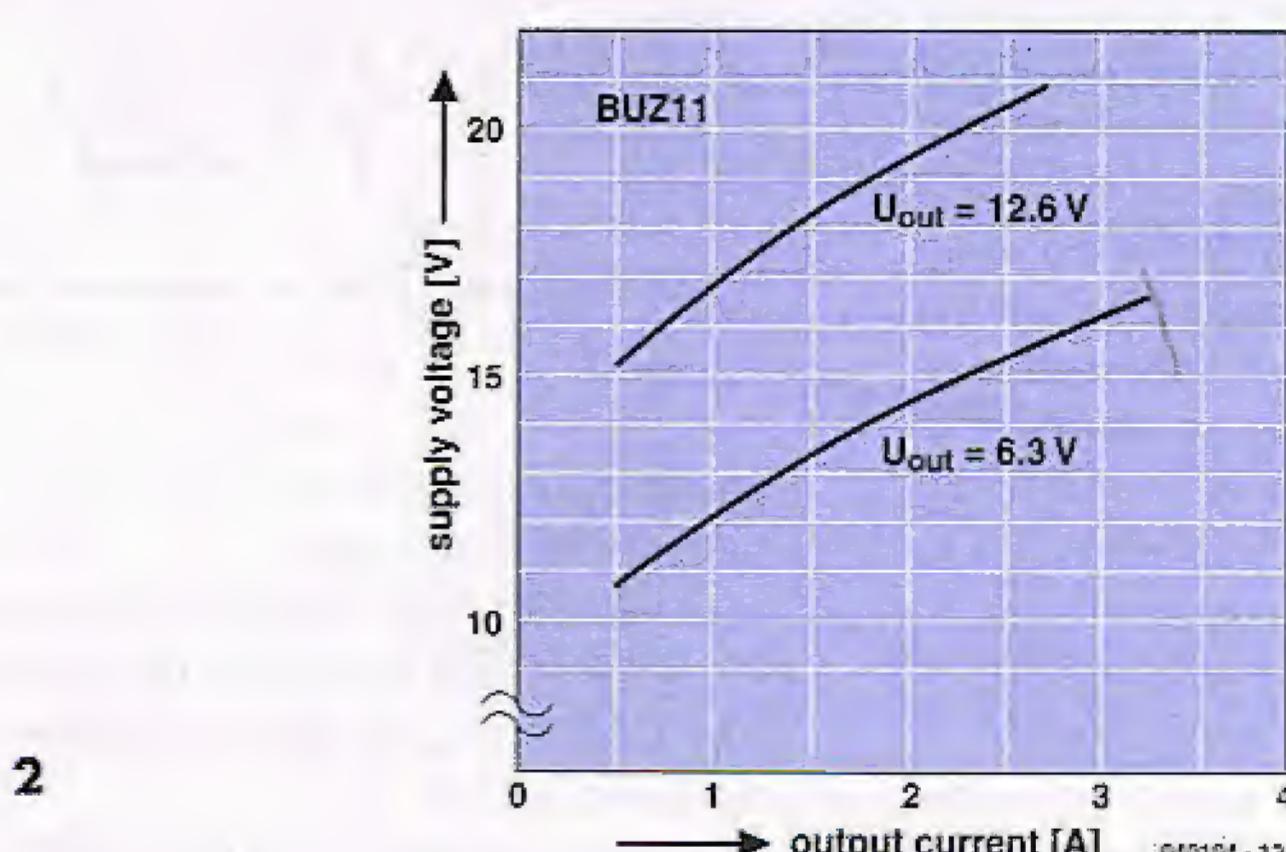
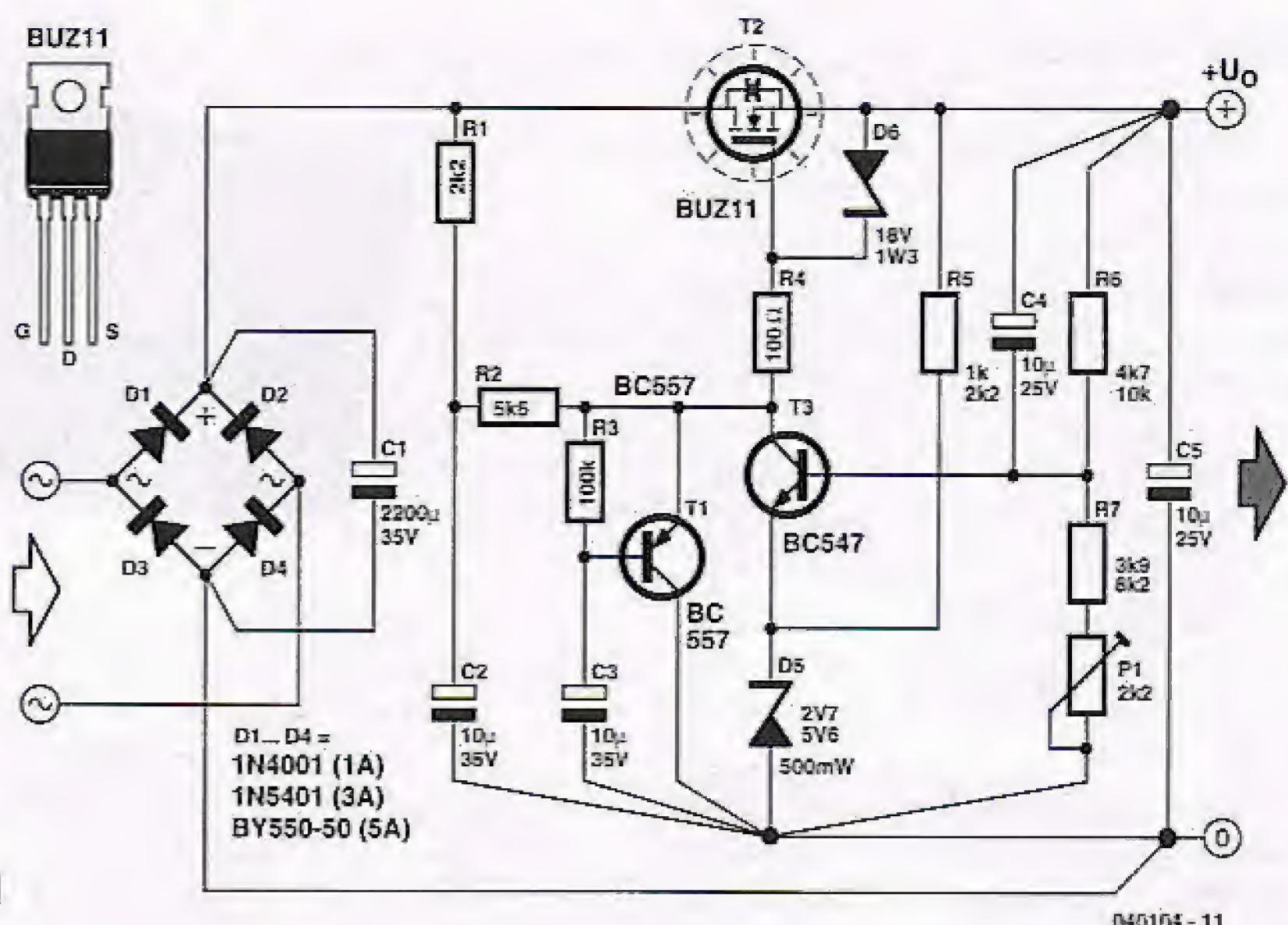
Valves are enjoying increasing popularity in audio systems. With the European 'E' series of valves, such as the ECC83 (12AX7) and EL84 (6BQ5), the filament voltage is 6.3 V. Depending on how the circuit is wired, the ECC 81-83 series of twin triodes can also be used with a filament voltage of 12.6 V. In earlier times, the filament voltage was usually taken directly from a separate transformer winding, which (in part) was responsible for the well known 'valve hum'.

With regard to the signal path, current valve circuits have hardly experienced any fundamental changes. In high-quality valve equipment, though, it is relatively common to find a stabilised anode supply. Mains hum can have a measurable and audible effect on input stages whose filaments are heated by an ac voltage. The remedy described here is a stabilised and precisely regulated dc filament voltage. The slow rise of the filament voltage after switching on is also beneficial. The exact setting of the voltage level and the soft start have a positive effect on the useful life of the valves.

**Figure 1** shows a voltage regulator meeting these requirements that is built from discrete components. The two sets of component values are for a voltage of 6.3 V (upper) and 12.6 V (lower). Thanks to the fact that the supply works with a constant load, it can do without special protective circuits and the additional complexity of optimum regulation characteristics for dynamic loads.

The circuit in Figure 1 consists of a power MOSFET configured as a series-pass regulator and a conventional control amplifier. Zener diode (D5) sets the reference potential. A constant voltage is thus present at the emitter of the BC547 control amplifier (T3). The current through D5 is set to approximately 4–5 mA by series resistor R5.

The output voltage  $U_O$  (the controlled variable) acts on the base of the control amplifier (T3) via voltage divider  $R_6/R_7$ . If the output voltage drops, the collector current of T3 also decreases, and with it the voltage drop across load resistors  $R_1$  and  $R_2$ . The voltage on the gate of the MOSFET thus increases. This closes the control loop. The values of the resistors forming the voltage divider are chosen for



the usual tolerances of Zener diodes, but they must be adjusted if the diode is out of spec (which can happen).

The load resistance of the control amplifier is divided between R1 and R2. The current through the load resistance and the collector current of T3 are practically the same, since the MOSFET draws almost no gate current. Filter capacitor C2 is connected to the junction of R1 and R2 to reduce residual hum. Electrolytic capacitor C4 and power supply filter capacitor C1 serve the same purpose. The hum voltage also depends on the magnitude of the load current.

The voltage drop over the series-pass regulator is nearly the same for an output voltage of 6.3 V or 12.6 V. With a BUZ11 and a load of 1 A at 6.3 V, for instance, the average voltage across the source-drain channel is approximately 7 V. The power dissipation of 7 W requires a corresponding heat sink.

The slow rise of the output voltage is due to the presence of timing network R3/C3 and T1. When power is switched on, T1 holds the gate of the MOSFET at nearly ground level. As C3 charges, T1 conducts increasingly less current, so ultimately only the control transistor affects the gate voltage.

The mains transformer must be selected according to the required load current. The required value of the input voltage can be read from the chart. The transformer should have a power rating at least 30 % greater than what is necessary based on the calculated load dissipation. Where possible, preference should be given to a filament voltage of 12.6 V. When twin triodes in the ECC81-83 series are used, for example, the power dissipation in the series pass transistor is lower with a voltage of 12.6 V.

# IR Transmitter with HT12E

Peter Verhoosel

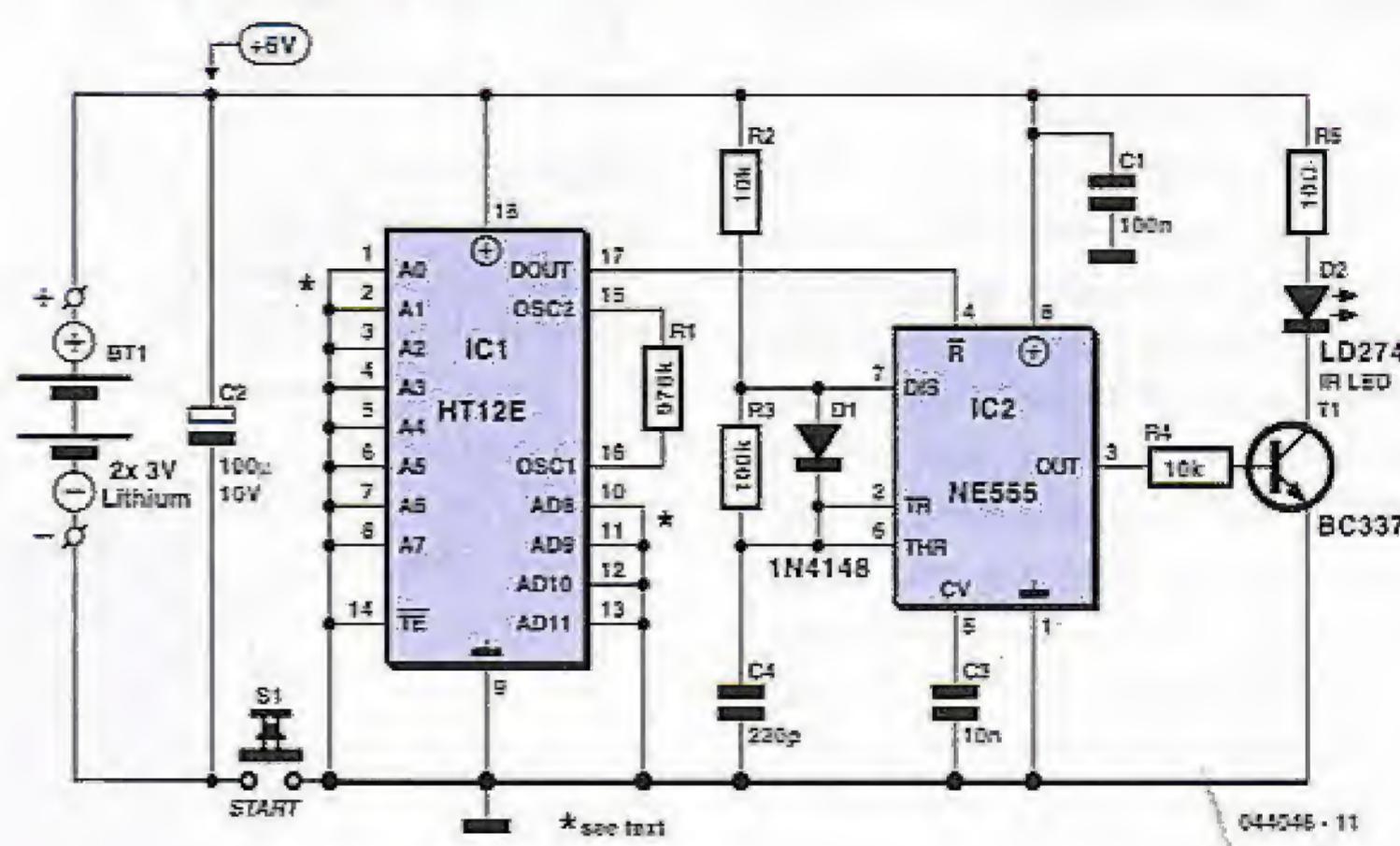
IR (infra-red) transmitters containing the encoder-IC HT12E from Holtek have been published in *Elektor Electronics* on previous occasions. The interesting aspect of this design is that the entire IR-transmitter has been squeezed into a handy key ring.

The operation of the encoder IC HT12E has already been thoroughly dealt with in earlier publications. It will suffice to mention here that an address can be programmed on inputs A1 through to A8. This address has to be set the same as in the receiver.

On the circuit board, the address lines are connected to ground with a thin piece of track so that address zero is selected. By cutting the track with a sharp knife the corresponding input can be made logic high. This change of address is only necessary when more than one transmitter is active in the same house.

The same story applies to the four data lines, but that is not relevant if you use the IR Multi-Position Switch published elsewhere in this magazine.

The generated code is available on pin 17 of IC1, which is modulated with the aid of IC2 on a carrier of 40 kHz. Transistor T1 drives the infrared LED via R4, so that an IR code is transmitted. Two Lithium cells of 3 V each power the circuit. The circuit is only powered when transmit pushbutton S2 is pressed. The life



expectancy of the batteries is during normal use more than a year.

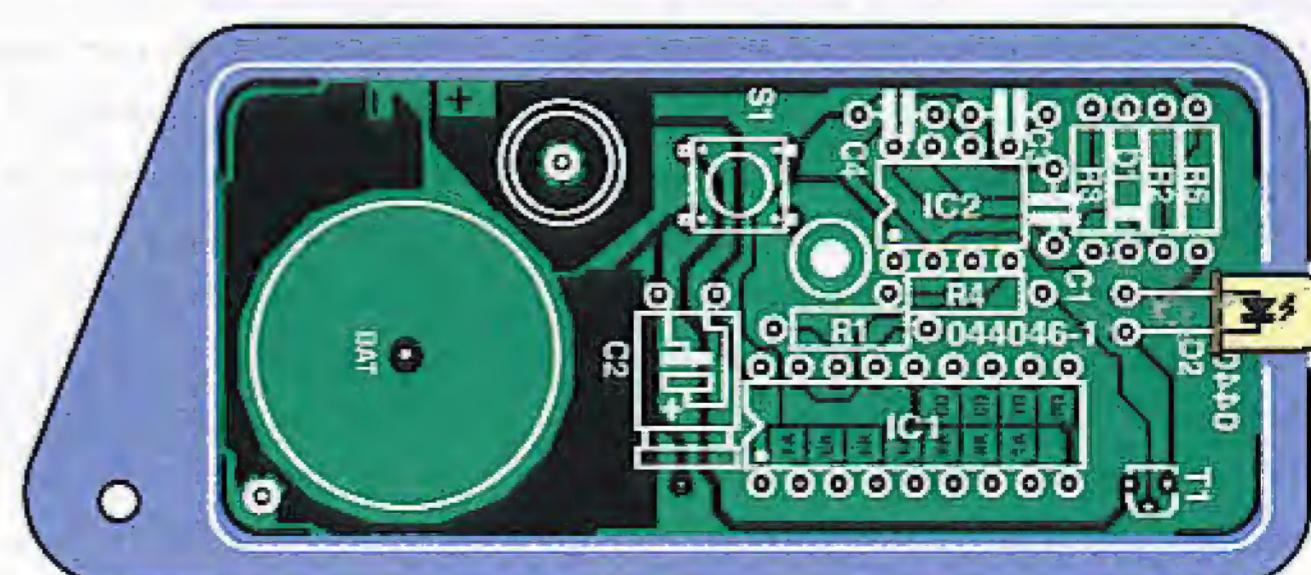
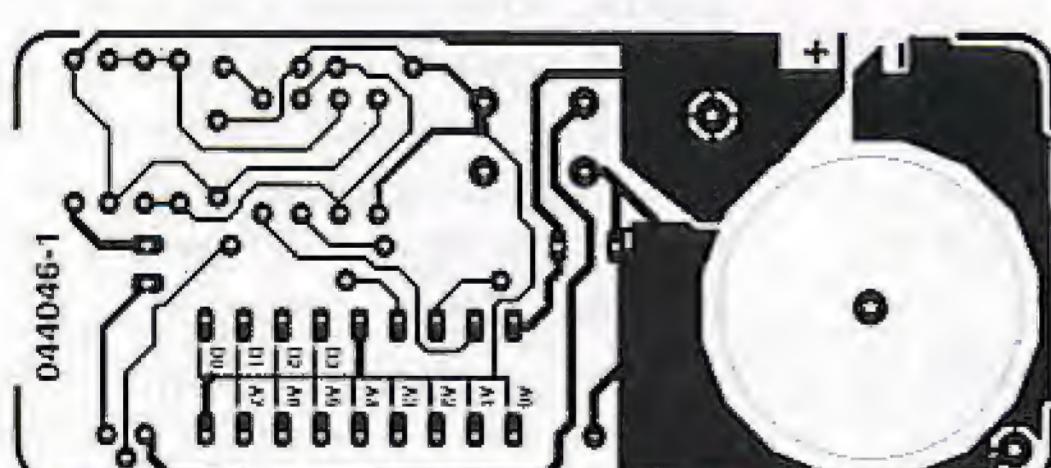
The construction itself should be no problem. However, note the height of the components. For this reason an IC socket cannot be used.

A paperclip soldered to the bottom acts as a battery holder, this is ground.

For the top part of the battery holder we use an automotive connector and an M3 bolt.

Because the height of T1 can be a problem when closing the enclosure, the device is best bent flat on the PCB before soldering.

- 1 -



# COMPONENTS LIST

## Resistors:

$$\begin{aligned} R_1 &= 976\text{k}\Omega \\ R_2, R_4 &= 10\text{k}\Omega \\ R_3 &= 100\text{k}\Omega \\ R_5 &= 100\text{k}\Omega \end{aligned}$$

## Capacitors

**Capacitors:**  
C1 = 100nF  
C2 = 100 $\mu$ F 10V radial  
C3 = 10nF  
C4 = 220nF

## Semiconductors:

**Semiconductors:**  
D1 = 1N4148  
D2 = IRED (e.g., LD274)  
IC1 = HT12F (Holtek)

IC2 = TLC555  
T1 = BC337

#### Miscellaneous:

**Miscellaneous:**  
S1 = miniature pushbutton (HAK)  
Enclosure: KM series Box UM14  
PCB: available from The PCB Shop

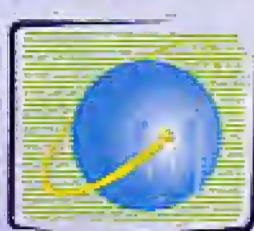
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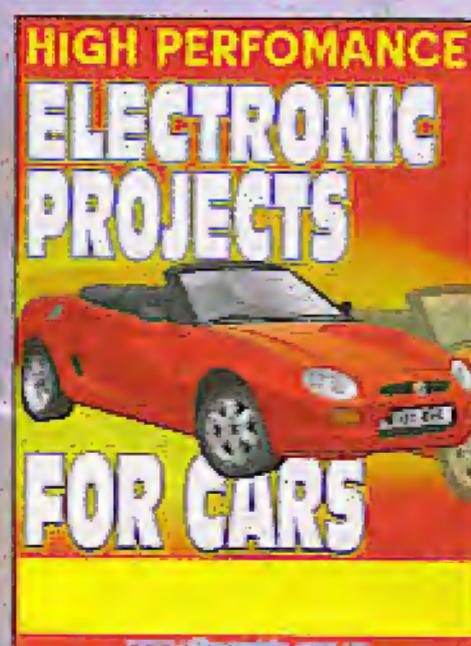
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# USB/I2C INTERFACE

Paul Goossens



Since the introduction of the I<sup>2</sup>C bus in the eighties by Philips it has been used many times to provide a simple connection between a PC and home-built circuits. This often made use of a simple interface connected to the parallel port of the PC. This now seems a bit dated, so we've designed a USB/I<sup>2</sup>C interface for you to build.

# RFACE

## I-square-C rules...

Articles about the I<sup>2</sup>C bus have appeared several times in *Elektor Electronics*. We have even published designs for a whole range of modules that communicated with a PC via the I<sup>2</sup>C bus. At that time we used an ISA card to provide an I<sup>2</sup>C interface. Another type of interface that was frequently used was a simple circuit that connected to the parallel port.

But with the introduction of modern operating systems it became much more difficult to control the parallel port correctly. The old software would often no longer function properly.

We have designed a new I<sup>2</sup>C interface, which uses the USB bus instead of the parallel port to connect to the PC, so that it can be easily used with newer PCs and modern operating systems.

### I<sup>2</sup>C history

Philips originally developed the I<sup>2</sup>C bus to provide communication facilities between the various chips found in television, video recorders, etc., without taking up too much space on the PCB. The result is that the I<sup>2</sup>C bus requires only two signal lines instead of 8 datalines, several address lines and a few control lines, which was the case up to then.

Once this bus was in common use, various other chips were designed with an I<sup>2</sup>C interface by Philips as well as other manufacturers. Many chips were designed for use in audio and video equipment, such as tone controls, synthesizers, volume controls, and so on. The range has been extended since then and now includes digital I/O buffers, A/D converters etc., giving us a wide range of I<sup>2</sup>C devices to choose from.

### I<sup>2</sup>C operation

The I<sup>2</sup>C interface is a so-called master-slave bus. This means that every I<sup>2</sup>C

### Quick specifications

- Compact
- USB 1.0 full-speed interface
- Compatible with USB2.0 hosts
- Works with Windows 98SE to Windows XP
- Doesn't require separate driver software
- The maximum cable length between the interface and modules is at least 100 metres!
- I<sup>2</sup>C frequency: 100 kHz
- Simple to use by means of a DLL
- Source code for the firmware, DLL and example program is available
- Uses a 9 V mains adapter as the power supply

bus has one master device, with all other devices acting as slaves. The master is always responsible for supplying the clock signal on the bus. Every transaction may be initiated by the master only. A slave should therefore never start transmitting data on its own accord.

Each slave on the I<sup>2</sup>C bus has its own unique address. Every transaction begins with a START condition, followed by a 7-bit address and a R/W bit. If a slave with this address is present on the bus it will send an ACK (acknowledge) signal to confirm that it has recognised its address. All the other I<sup>2</sup>C slaves will now ignore the data on the bus and will only start listening again after a STOP condition has been detected on the bus.

The R/W bit is used to inform the slave whether the master wants to read or write data. When this bit is a '1', the master wants to read data. In this case, the next byte will be put onto the bus by the slave. If this bit is '0' (Write), the following byte(s) will be transmitted by the master. The

master still generates the clock signal in both cases.

At the end of the communication is a STOP condition and the whole process then repeats itself.

### Interface

The interface we've designed should satisfy several requirements. We would like to keep the installation under Windows as easy as possible. What's more, it should be (relatively) easy to control the interface. It would also be nice if we could run longer cables between the interface and I<sup>2</sup>C modules, so the user can connect devices that are a long way away from the PC.

Our first task was to search for a suitable controller with a USB interface. We decided to use a TUSB3410 made by Texas Instruments, as this microcontroller has both a USB as well as an I<sup>2</sup>C interface. This is described (somewhat misleadingly) as a 'USB to Serial Port Controller'. In fact this is an 8051 compatible controller with a USB inter-

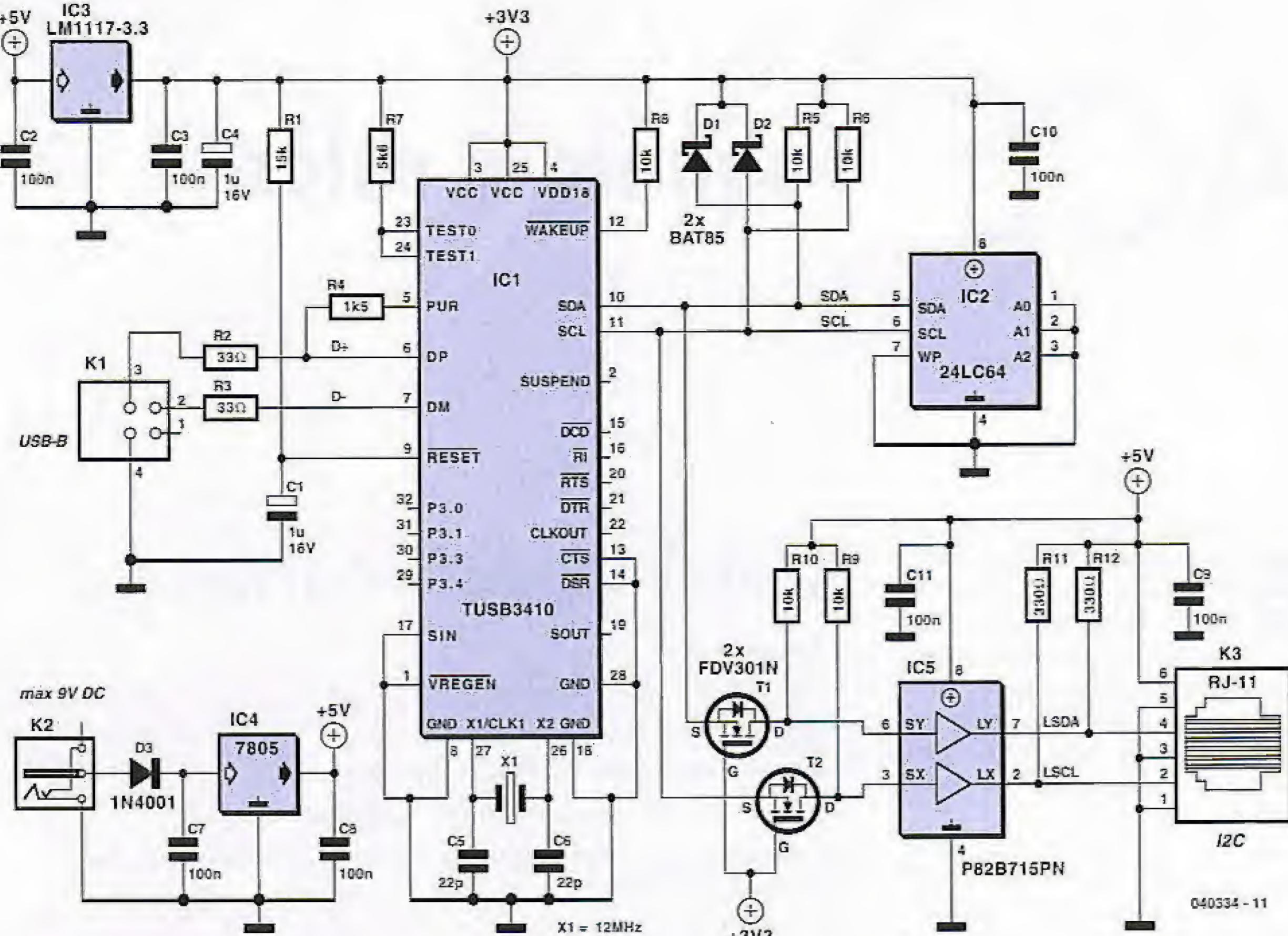


Figure 1. The circuit for the interface is built round a TUSB3410.

face, 16 kBytes of program memory, an enhanced serial port and an I<sup>2</sup>C interface. All these goodies are contained within a small 32-pin SMD package. To satisfy the requirement for the I<sup>2</sup>C connection to work over greater distances, we have given the signals an extra boost with the help of a P82B715PN I<sup>2</sup>C bus extender.

## Circuit diagram

The circuit diagram for our interface is shown in Figure 1. At the heart of the circuit is the TUSB3410 (IC1) with its associated oscillator (X1, C5 and C6). We've used an external mains adapter for the power supply. Its 9 V output is stabilised down to 5 V by IC4. There is also a requirement for a 3.3 V supply for the processor and the I<sup>2</sup>C EEPROM. For safety reasons we decided not to supply the circuit with power directly from the USB bus. The 5 V supply is also brought out on this connector and an overload or short could damage the USB interface in the PC.

The data lines from the USB connector (K1) are connected via resistors R2 and R3 to the appropriate data inputs of

the controller. The D+ line is connected via a 1k5 pull-up resistor to the PUR (Pull-Up Resistor) output of IC1. Normally this resistor is connected to the positive supply. This is required for a USB hub to detect that a full-speed USB device is connected to the USB port. By connecting this pull-up resistor to an output of the controller, the controller itself can tell the USB hub that a device is present. The reverse is also possible in that the controller can fool the hub that the device has been disconnected, by forcing this output low. This process is important during the booting of the chip (refer to the inset on booting the TUSB3410). The firmware is stored in an I<sup>2</sup>C EEPROM (IC2) and is connected to the controller via the I<sup>2</sup>C bus. Diodes D1 and D2 absorb any potential voltage spikes and protect both I<sup>2</sup>C signal inputs of the controller. R5 and R6 are the pull-up resistors that have to be present on every I<sup>2</sup>C bus.

You will have noticed that the I<sup>2</sup>C bus of the controller works at 3.3 V. These signals are not suitable for use in combination with a 5 V chip. Unfortunately, the I<sup>2</sup>C bus-extender is a 5 V device, so

both I<sup>2</sup>C signals first have to be converted to a 5 V level. This is taken care of by components T1, T2, R9 and R10. The P82B715PN I<sup>2</sup>C bus extender along with R11 and R12 allow longer cables to be connected to the I<sup>2</sup>C bus by lowering the impedance and increasing the current output. These signals are then taken to the outside world via K3.

The double-sided PCB shown in Figure 3 is very small, but still has all the required connectors on board. Mounting the components shouldn't be very difficult, with the exception of the SMDs: IC1, T1 and T2. It's still possible to solder the two transistors using a soldering iron with a fine tip, but it becomes more difficult with the IC. The IC should first be fixed in the right place on the board with a drop of glue. Then solder all pins together as well as to the solder pads. You should work quickly to avoid the IC becoming too hot. After everything has cooled down again you should place a clean piece of desoldering braid across the pins and remove the excess solder (i.e. the shorts between the pins). Don't attempt this with a solder sucker! Take

care at all times that the IC doesn't overheat. You should finally inspect all pins with a magnifying glass and multi-meter to check that they are connected properly and that there aren't any shorts left.

This completes the trickiest part of the construction.

An example of a suitable module that can be connected to the interface is shown in the **I<sup>2</sup>C Home Bus** article. If you prefer to use the I<sup>2</sup>C bus without the I<sup>2</sup>C bus-extender, you should make the following modifications:

IC5, R11 and R12 can be left out. Pins 3 and 2 on IC5 have to be connected together, as do pins 6 and 7. This is easily done by putting two short

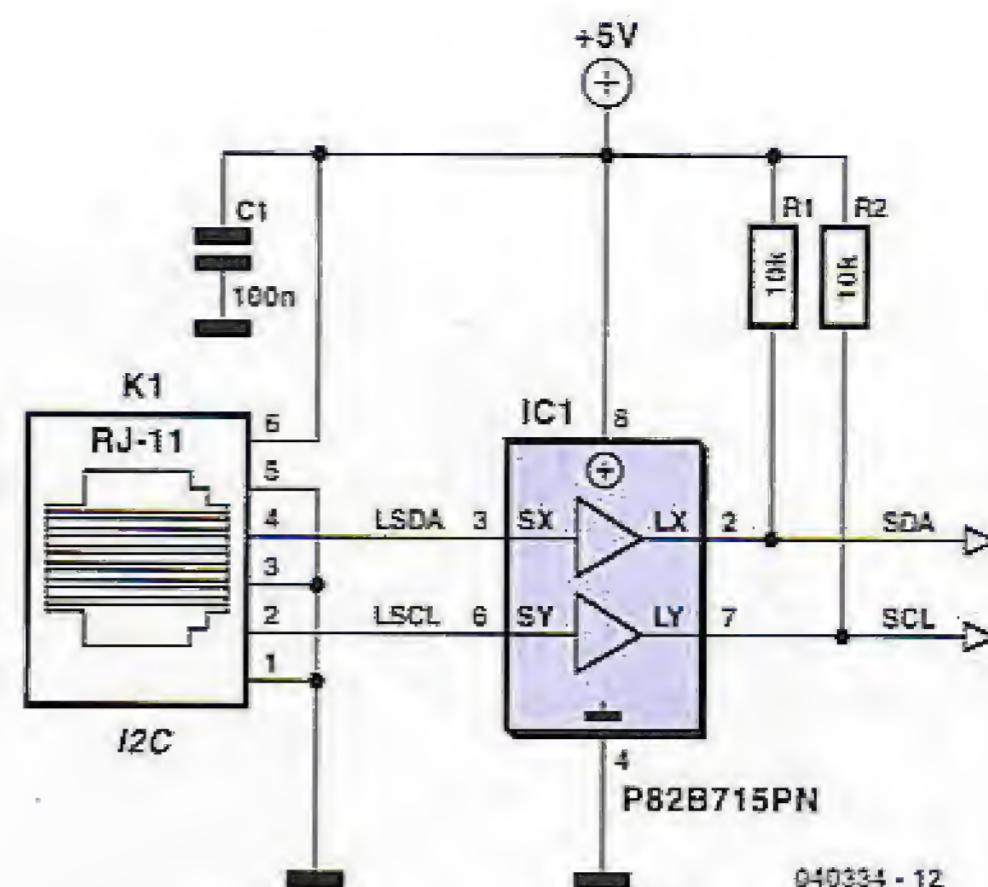


Figure 2. Input circuit for I<sup>2</sup>C modules when the I<sup>2</sup>C I/O-extender (IC5) is used.

## COMPONENTS LIST

### Resistors:

R1 = 15kΩ  
 R2,R3 = 33Ω  
 R4 = 1kΩ5  
 R5,R6,R8,R9,R10 = 10kΩ  
 R7 = 5kΩ6  
 R11,R12 = 330Ω

### Capacitors:

C1,C4 = 1μF 16V radial  
 C2,C3,C7-C11 = 100nF  
 C5,C6 = 22pF

### Semiconductors:

D1,D2 = BAT85  
 D3 = 1N4001  
 IC1 = TUSB3410 (Digikey # 296-12699-ND)  
 IC2 = 24LC64, programmed, order code **040334-21**  
 IC3 = LM1117-3.3 or LD1117V33C (Digikey # 497-1492-5-ND)  
 IC4 = 7805  
 IC5 = P82B715PN (Farnell # 559-258; RS Components # 821-784)  
 T1,T2 = FDV301N (Farnell # 995-848; RS Components # 354-4907)

### Miscellaneous:

K1 = USB-B connector, angled, PCB mount (Farnell # 152-754)  
 K2 = mains adapter socket PCB mount  
 K3 = 6-way RJ-11 connector (Farnell # 393-8359)  
 X1 = 12MHz quartz crystal  
 USB cable

PCB, order code **040334-1** (see Readers Services page)

Disk, project software, order code **040334-11** or Free Download

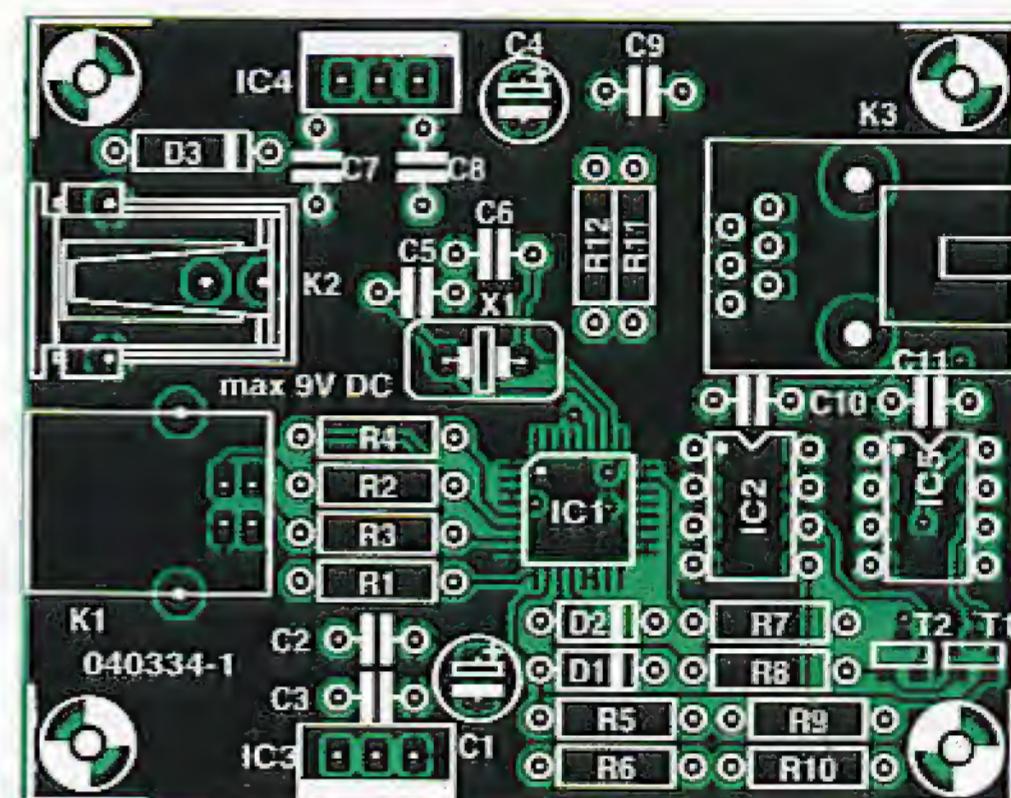
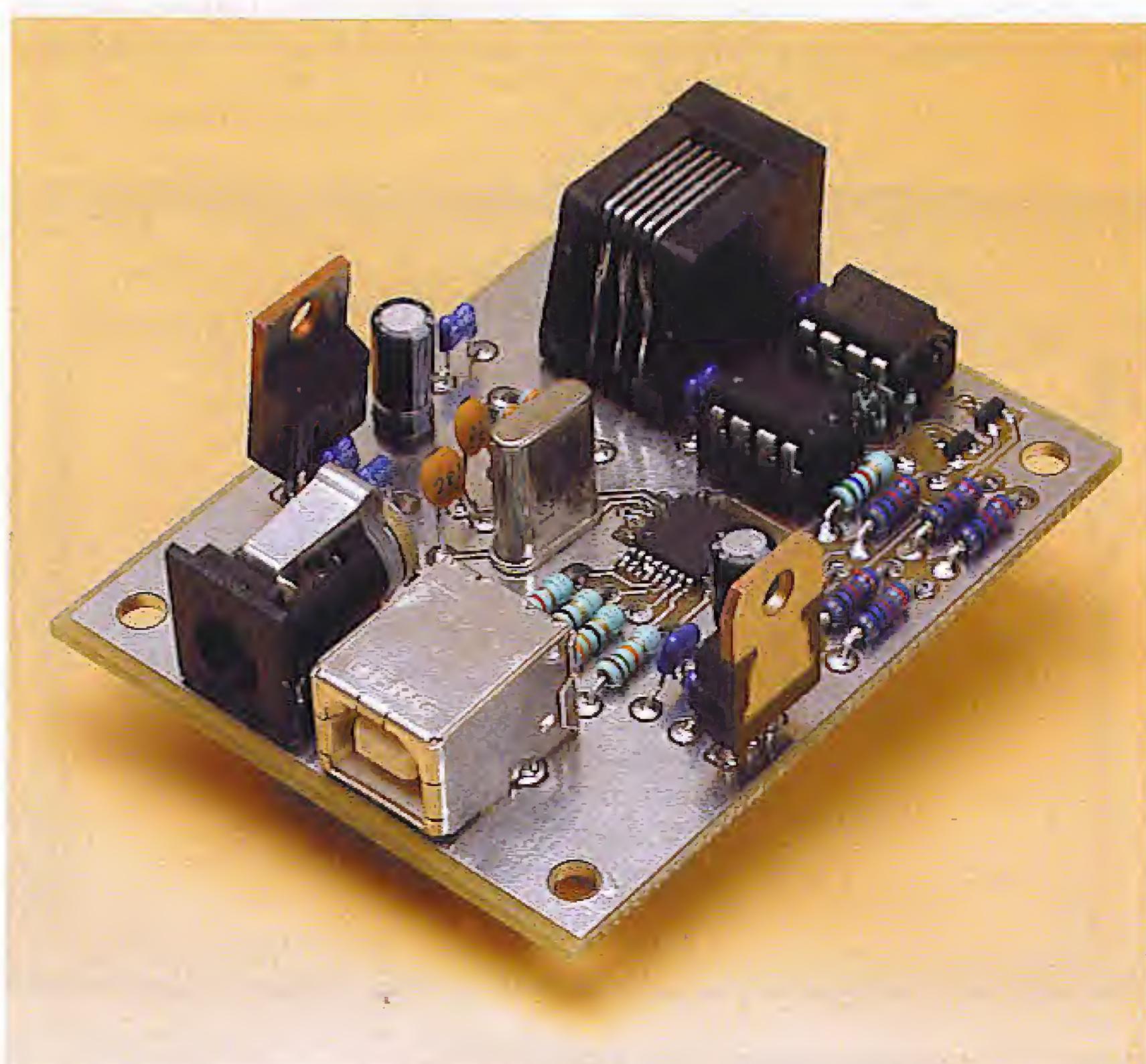


Figure 3. The PCB for the interface. IC1, T1 and T2 are SMDs and have to be soldered carefully using a fine tip. (copper track layout from our website)



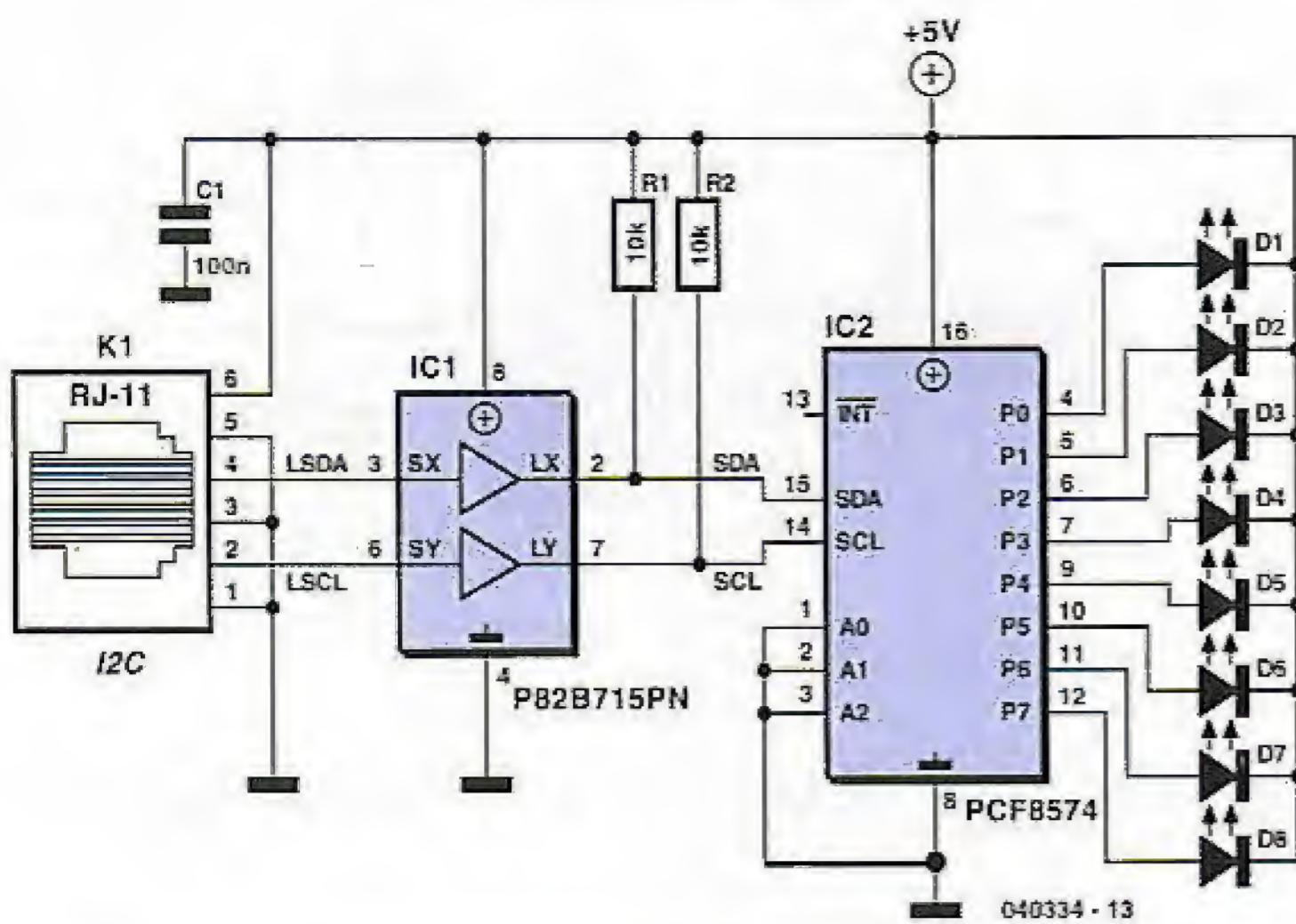


Figure 4. This circuit can be built to help test the interface.

wires into the IC socket. The modules may now connect the SCL and SDA lines directly to the I<sup>2</sup>C connections of their ICs.

If the I/O extender circuit is included on the PCB, it is essential that all connected modules have the input circuit shown in Figure 2.

## Installation and DLL

Installing the circuit is fairly straightforward. First you have to connect the mains adapter, then you can connect the circuit to the PC using a USB cable.

Windows (from 98SE onwards) will immediately recognise it as a HID device and after some rattling of the hard drive Windows announces that the device is ready for use.

But there is more to it than that of course. We also need to write a program that makes use of the interface. Its functions obviously depend on the modules that are connected and what you want to do with them. We realise that controlling a HID device isn't exactly a piece of cake for the average programmer. This is why we've made a DLL available which was specially

written to control our USB interface. We would recommend that this DLL is copied to the C:\Windows\System32 folder. This makes the DLL available to the operating system at all times and you don't have to copy the DLL to the folder where the application using this DLL is stored!

This DLL can be used with any programming language that supports the use of external DLLs. A few examples of such languages are Visual Basic, Visual C++, Delphi and Borland C++ Builder.

## Two methods

You can use the DLL from your application in one of two ways. When we wrote the DLL it seemed logical to make the application pass an array of bytes, where the DLL could either store the received bytes or read the bytes to be transmitted.

Most programming languages don't have a problem with the use of arrays as arguments in DLL functions. But it's a bit different with Visual Basic. Although it is possible with this programming language, it is a lot trickier for the novice Visual Basic programmer. For this reason we have included a few extra functions and procedures which make it easier to use the interface under Visual Basic.

To help you on your way we have written two simple examples in Visual Basic and Delphi, which control a standard I<sup>2</sup>C I/O extender. These examples show the two methods in which the DLL can be used.

The circuit of the module required for the examples is shown in Figure 4. The circuit is simple enough for it to be built on a piece of experimenter's board.

## Get to work with Word

In the June edition of Elektor Electronics we showed how the well-known word processor MS-Word could also be used to write your own programs. Since most Windows users have a copy of this word processor, it made sense to show you a simple example, written using Word. We have of course kept this example fairly simple and didn't use any arrays when communicating with the DLL!

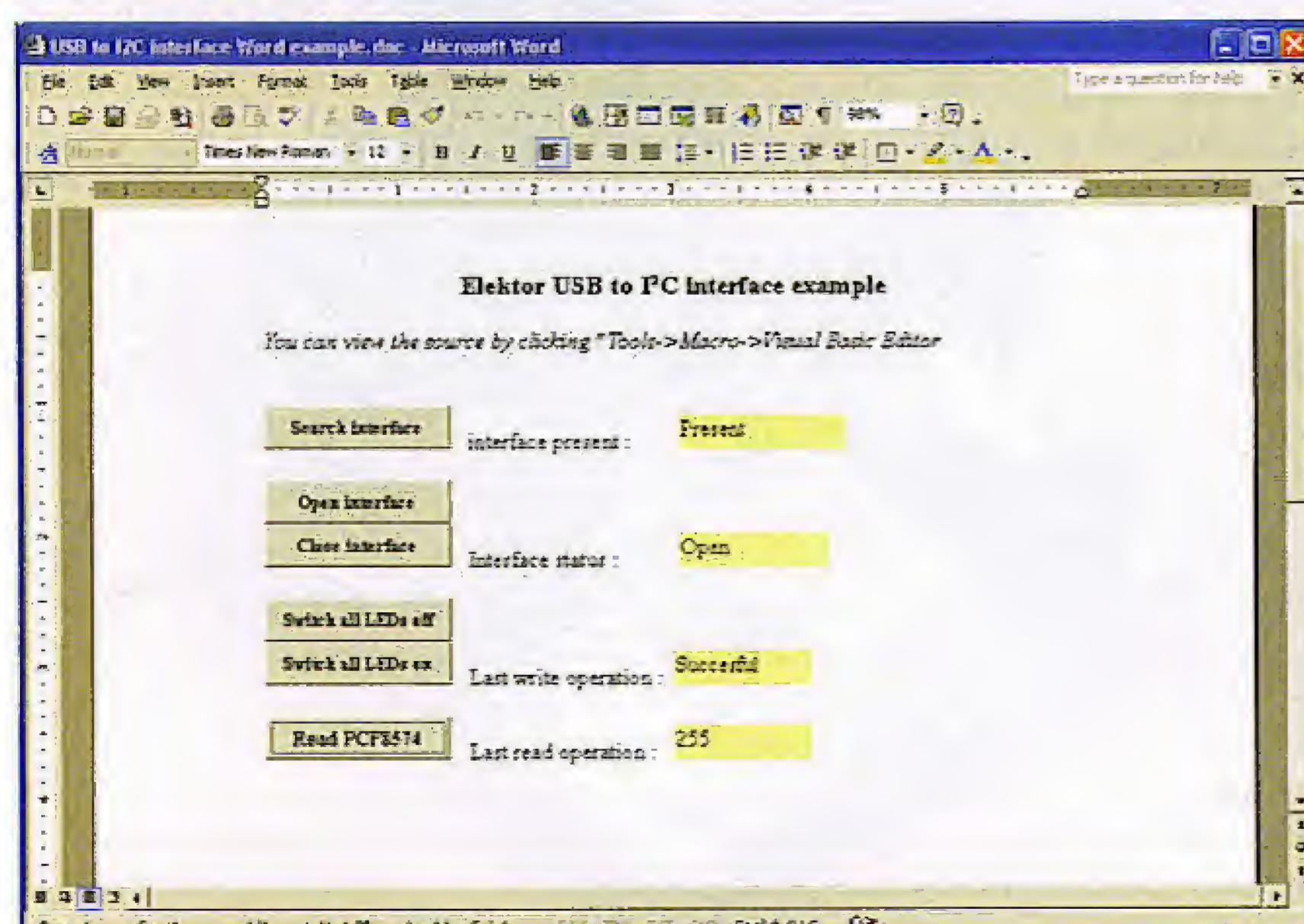


Figure 5. An example program in MS-Word.

The required file is part of the project software (order code 040334-11) and can be found in the folder 'Word example'. When you open this document you may, depending on the security settings of Word, get a question asking if you want to use macros in this document. You should answer this question with 'yes', otherwise the example won't work.

You should then see the document on the screen as shown in **Figure 5**. When you press the top button the software searches for the interface. The box next to this button shows whether the interface has been found or not.

Before we can use the interface, it must first be opened. This requires a mouse click on the button 'Open interface'. Once you have finished using the interface, it should be closed with a click on the button 'Close interface'. The result of a click on these two buttons can be seen on the associated yellow pane.

The next two buttons are used to turn the LEDs on and off (you have of course built and connected the circuit shown in **Figure 4**, haven't you?). You can obviously tell from the LEDs on the module if the data was successfully sent, but as you may have gathered, this is also shown in the box to the right of these buttons.

The final button is used to show the status of the inputs of the PCF8574. The value returned by the PCF8574 is shown in the window to the right of this button.

A more detailed explanation is given in the sidebar for 'Using the DLL without arrays'. This sidebar and the source code of the Word document should be enough for a programmer to understand how it all works.

## Delphi

Our second example is a very simple application written in Delphi. A question we're sometimes asked is why we use the Delphi language so often in our examples. The reason this programming language is so useful for examples is that it is derived from Pascal and easy to follow. A C programmer should also be able to follow it without problems. The opposite is not true, since a Pascal programmer would have great difficulty in following a C program.

The files for this example can be found in the folder 'Delphi example'. The

## DLL functions

### Standard:

```
type TReport = array[0..200] of Byte;
function I2C_USB_Present : Boolean; stdcall;
function I2C_USB_Opened : Boolean; stdcall;
function I2C_USB_Open : Boolean; stdcall;
procedure I2C_USB_Close; stdcall;
```

### Communication using a program buffer:

```
function I2C_USB_Write (adr : Byte; length : Byte; data : array of Byte) : Boolean;
stdcall;
function I2C_USB_Read (adr : Byte; length : Byte; var data : array of Byte) :
Boolean; stdcall;
```

### Communication using the DLL buffer:

```
procedure I2C_USB_ClearWriteBuffer; stdcall;
procedure I2C_USB_ClearReadPointer; stdcall;
procedure I2C_USB_FillBuffer (data: Byte); stdcall;
function I2C_USB_GetBuffer : Byte; stdcall;
function I2C_USB_WriteWithBuffer (adr : Byte) : Boolean; stdcall;
function I2C_USB_ReadWithBuffer (adr:Byte; length:Byte) : Boolean; stdcall;
```

## Booting the TUSB3410

The TUSB3410 has a unique way of initialising itself at power-up. In contrast to many of its modern contemporaries, this controller doesn't have on-chip flash memory for storing programs. Instead, it has ordinary RAM for the programs. Consequently, this memory will be completely blank at the start-up. Texas Instruments has included a small program in ROM that is executed at start-up, which cleverly loads a program into RAM. This can happen in two ways.

The boot program first checks if an I<sup>2</sup>C EEPROM is connected to the I<sup>2</sup>C bus. If this isn't the case, the controller announces itself on the USB-bus with a certain Vendor-ID and Product-ID. As long as the correct driver has been installed in Windows (freely available from the website of Texas Instruments, <http://www.ti.com>), it will be recognised by Windows as a 'TUSB3410 boot device'. This then causes Windows to send the firmware to the controller. The exact mechanism of this process is explained in the documentation from Texas Instruments. The controller stores the received firmware in its program RAM and then disconnects from the USB bus. The controller then switches to its normal operating mode and starts executing the firmware in the program RAM.

The first method of starting up is the one we've used for our controller. With this method all of the firmware is stored in an I<sup>2</sup>C EEPROM. The boot program in the controller knows from the header (the first few bytes in the EEPROM) that this EEPROM contains the firmware. Once it has verified that the header is correct, the controller will read the rest of the EEPROM and store it in its program memory. Once that has completed the controller switches to its normal mode and starts executing the firmware. This method has the big advantage that the end user (that's you) doesn't have to install the device driver from Texas Instruments on the PC.

You may well ask what happens when you have two different devices, each using a TUSB3410, but with totally different firmware; how would Windows know what firmware had to be sent to which device? The way round this problem is to provide each USB device with a unique combination of a Vendor-ID and Product-ID. These are stored in the EEPROM and are transmitted by the boot program when it announces itself on the USB bus. The documentation provided by Texas Instruments explains how you can edit the 'inf' file for the TUSB3410 and make it use different firmware for different combinations of the VID and PID.

More information regarding the boot-up process of the TUSB3410 can be found on the website of Texas Instruments.

source code has been kept as compact as possible, which resulted in a single procedure (*Timer1Timer*) for all communication with the interface. This procedure is also responsible for detecting and opening the interface. Immediately afterwards the program reads and writes to the PFC8574, which you had already connected to the I<sup>2</sup>C bus, of course!

We would like to reassure you that it's not a problem if you open the inter-

face as soon as your program starts and if you close it when the program finishes. In this case we did this in a timer routine that is called twice a second. You can therefore connect and disconnect the USB interface at will while the program runs.

face, where we can control various peripherals (see 'I<sup>2</sup>C Home Bus'). It is also possible to design your own modules and to control them using this interface. You will of course need some programming experience under Windows for this.

(040334-1)

## Follow-up

This edition of *Elektor Electronics* also contains an application for this inter-

# Using the DLL

## without arrays

### In general:

**I2C\_USB\_Open** This is called to gain access to the interface. The function returns 'true' when permission is granted.

### Reading an I<sup>2</sup>C chip:

**I2C\_USB\_ClearReadPointer** This should be used to initialise a new read command.

**I2C\_USB\_ReadWithBuffer** takes care of the reading of bytes via the I<sup>2</sup>C bus. This function takes two arguments. The first is the I<sup>2</sup>C address of the device from which we want to read. The second argument specifies how many bytes (maximum of 255) have to be read. This function returns 'true' when the bytes have been successfully read.

The function **I2C\_USB\_GetBuffer** can then be used to read these bytes one by one.

### Writing to an I<sup>2</sup>C chip:

Before we send any data we should call the procedure

**I2C\_USB\_ClearWriteBuffer**. This procedure makes sure that we begin with a clean slate.

Next we use the procedure **I2C\_USB\_FillBuffer** to send the data to the DLL one byte at a time. The only argument for this procedure is the byte to be sent. After all bytes of the message have been sent to the DLL we only need to call the function **I2C\_USB\_WriteWithBuffer** to get these bytes sent via the I<sup>2</sup>C bus to the desired I<sup>2</sup>C device. This function takes the address of the receiving I<sup>2</sup>C device as argument.

## with arrays

### In general:

**I2C\_USB\_Open** This is called to gain access to the interface. The function returns 'true' when permission is granted.

### Reading an I<sup>2</sup>C chip:

In this case we only need one function to read data from the I<sup>2</sup>C device, which is **I2C\_USB\_Read**. This function takes three arguments. The first argument specifies the I<sup>2</sup>C address of the device that we want to communicate with. The second argument states the number of bytes we want to read. The final argument points to a buffer where the received bytes can be stored. This function returns 'true' when the communication went faultlessly.

### Writing to an I<sup>2</sup>C chip:

This command also requires just a single call to the DLL. The function **I2C\_USB\_Write** takes care of this task. The first argument specifies the I<sup>2</sup>C address here as well. The second argument specifies how many bytes we want to send. And finally, this function requires a buffer that contains the bytes to be transmitted. Just as with the previous function, the return value tells us if the communication went flawlessly.

N.B. Keep in mind that it's the responsibility of your program to make sure that the buffer is big enough to receive all the data!

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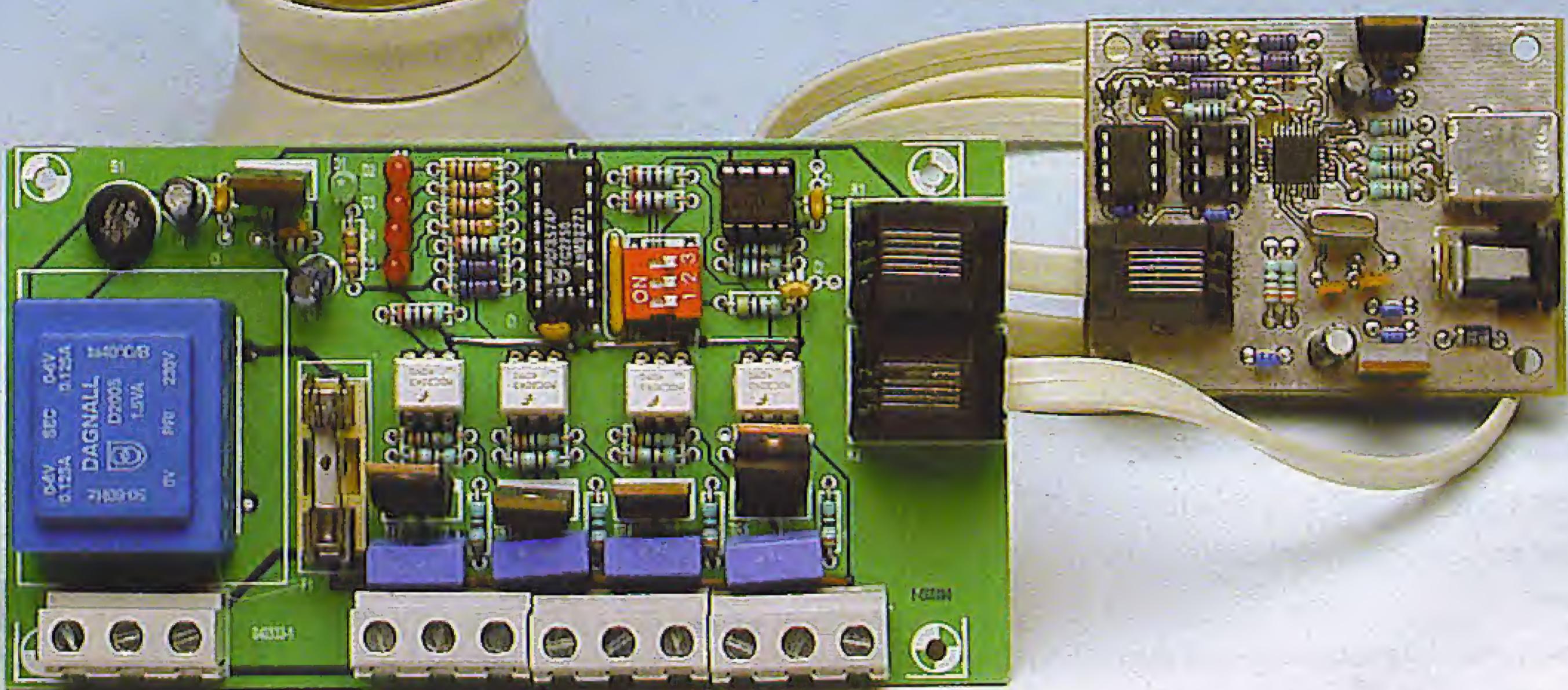
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# I<sup>2</sup>C-homebus

Paul Goossens

**Switch power outlets  
with your PC**



This unit, in combination with the USB/I<sup>2</sup>C interface described elsewhere in this issue, may be used to switch four mains-powered devices on and off via the PC. Eight of these modules may be connected to a single interface, allowing up to 32 loads to be controlled. The system is ideal for a small home bus!

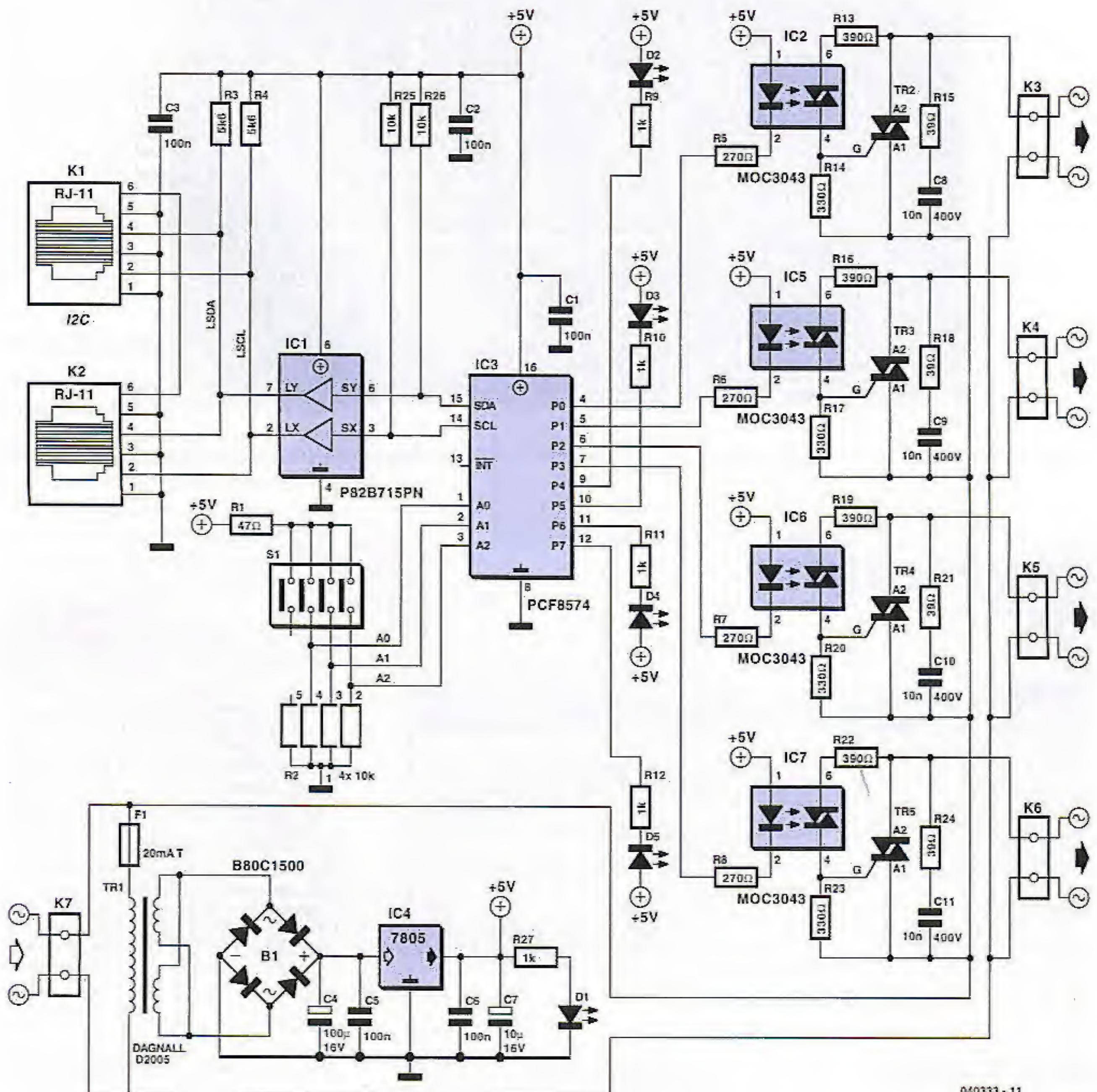


Figure 1. The essential elements in the circuit diagram are an I<sup>2</sup>C driver IC and a bus extender.

Triggered by other articles on home automation in this issue, you may feel like investigating the possibilities of automating, or at least remote controlling, a couple of electrical devices in and around your home. If you do not want to rush off to the high street stores to buy a box full of ready-made modules working on a more or less familiar protocol, then home construction of a small system is a perfectly viable alternative.

An I<sup>2</sup>C system can be used without problems for a small home bus com-

prising a couple of features for control and switching. Provided extra bus drivers are applied, distances of the order of tens of metres are easily covered. The connecting cable between the modules is reasonably simple as we employ 6-wire UTP cabling with RJ11 plugs. Also, there is a wide choice of ICs with I<sup>2</sup>C compatibility, serving an impressive number of applications.

At the PC side we already have a suitable circuit in the form of our USB/I<sup>2</sup>C interface. Thanks to its design, this

interface is capable of covering large distances and so forms the perfect starting point for a simple I<sup>2</sup>C-based Home Bus. At the 'device' side there are a great many possibilities when it comes to creating an I<sup>2</sup>C connection. In this article we describe a circuit that allows four mains-powered devices to be switched (TV, lighting, coffee machine, etc.).

Several modules may be connected to the bus, so quite a lot of electrical equipment in and around the home may be 'bused' in this way.

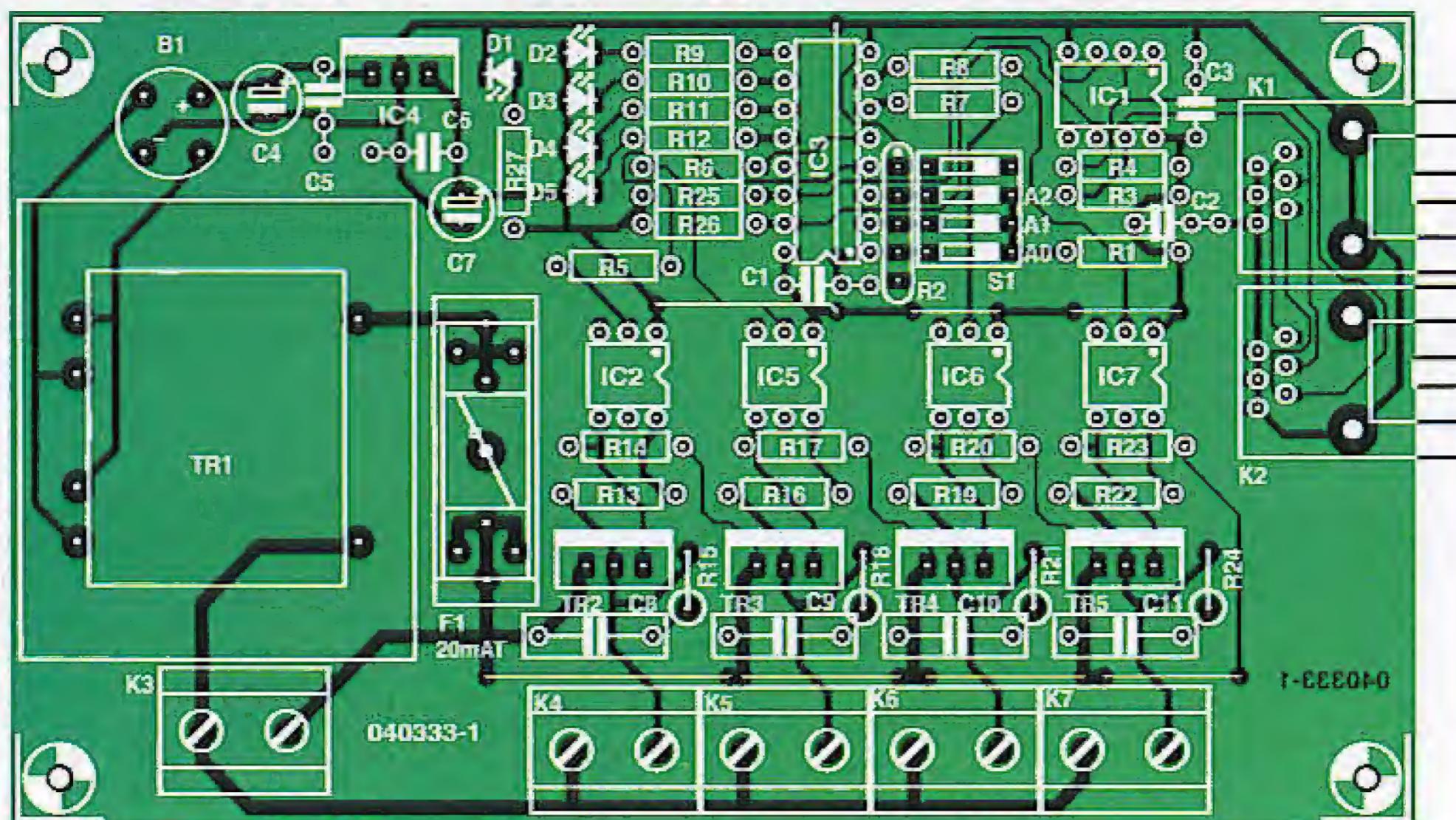


Figure 2. If you use this board, hardly anything can go amiss when building up the project. (copper track layout on our website)

## COMPONENTS LIST

### Resistors:

R1 = 47Ω  
R2 = 10kΩ 4-way SIL array  
R3,R4 = 5kΩ  
R5-R8 = 270Ω  
R9-R12 = 1kΩ  
R13,R16,R19,R22 = 390Ω  
R14,R17,R20,R23 = 330Ω  
R15,R18,R21,R24 = 39Ω  
R25,R26 = 10kΩ

### Capacitors:

C1,C2,C3,C5,C6 = 100nF  
C4 = 100μF 16V radial

C7 = 10μF 16V radial  
C8-C11 = 10nF, safety class X2

### Semiconductors:

B1 = B80C1500 in round case (80V piv, 1.5A)  
D1 = LED, green, low current  
D2-D5 = LED, red, low current  
IC1 = P82B715PN (Farnell # 559-258)  
IC2,IC5,IC6,IC7 = MOC3043 (Farnell # 885-710)  
IC3 = PCF8574 (Digikey # 296-13106-5-ND)  
IC4 = 7805  
Tr1 = mains transformer, PCB mount, sec. 2 x 6V/2 x 1.5 VA (Farnell # 926-280)

Tri2-Tri5 = TIC206D (Conrad Electronics # 186333)

### Miscellaneous:

F1 = fuse, 20mA (time lag), with PCB mount holder  
K3-K7 = 2-way PCB terminal block, lead pitch 7.5mm  
K1,K2 = 6-way RJ11 connector (Farnell # 393-8359)  
S1 = 3-way DIP switch  
RJ11 cable (Farnell # 754-948)  
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Disk; all project software, order code **040333-11** or Free Download

## Keep it simple

As you can see in the circuit diagram in Figure 1, the active part of the circuit consists of a remote 8-bit I/O expander type PCF8574 and an I<sup>2</sup>C bus extender type P82B715PN.

The PCF8574 in position IC3 contains an 8-bit bidirectional port and an I<sup>2</sup>C bus interface. The eight open-drain outputs can 'source' sufficient current to drive LEDs directly. Thanks to internal latches, the IC remembers the most recent configuration. Four output pins control the four status LEDs in the circuit; the other four connections each serving a mains output. Actually, the LEDs and triacs are controlled separately via the bus, but the software written for the system will automatically ensure each LED will always indicate the status of the associated mains

connection (i.e., triac).

Three pins (wired to DIL switch S1) allow one of up to eight module addresses to be set; meaning that up to eight of these circuits may be connected to a single bus — and addressed individually. It should be noted that the -A version of the PCF8574 has a different slave address range. If you use the PCF8574A in another eight modules, up to 16 modules may be connected to the bus. The bus extender IC, IC1, acts as a 'booster', increasing the currents through the I<sup>2</sup>C bus and so making it less susceptible to external interference. If, as in our example, UTP cable is used, then a distance of about 200 metres may be covered between PC interface and module — more than enough to 'wire' your average home we'd say.

Note that the extender IC has to be applied in all modules connected to the bus if it is also present on the USB/I<sup>2</sup>C interface board (or similar modules of your own design).

The connections with the I<sup>2</sup>C bus are routed via two RJ11 connectors on the board.

The mains-powered loads are switched on and off using a combination of an optoisolator and a triac. In this way we have a good electrical isolation between the mains on the one hand and the circuit and the Home Bus, on the other. The MOC3043 is an optoisolator with an internal diac and zero-crossing detector, which make it ideal for driving a triac.

The triacs used are the common-or-garden type TIC206D. They require a so-called snubber network to protect the device against voltage surges

across the anodes. In this case, we've added a series network of a 39-resistor and a 10-nF capacitor for each triac. If you want to use so-called snubberless triacs, then resistors R15/R18/R21/R24 and capacitors C8/C9/C10/C11 may be omitted. The low-voltage logic circuitry is powered from the mains using a transformer, a bridge rectifier, a reservoir capacitor and a 7805 voltage regulator. This power supply affords electrical isolation between the circuit and the mains network.

## Construction

The printed circuit board designed for the circuit (**Figure 2**) has a spacious layout with all connectors carrying mains voltages conveniently located at one side. Mounting the components onto the board is not expected to cause problems. However, do pay attention to the orientation of polarized components like electrolytic capacitors, LEDs and ICs.

It is wise to mount the circuit into a sturdy enclosure. For guidance on aspects related to electrical safety, consult the *Electrical Safety* page.

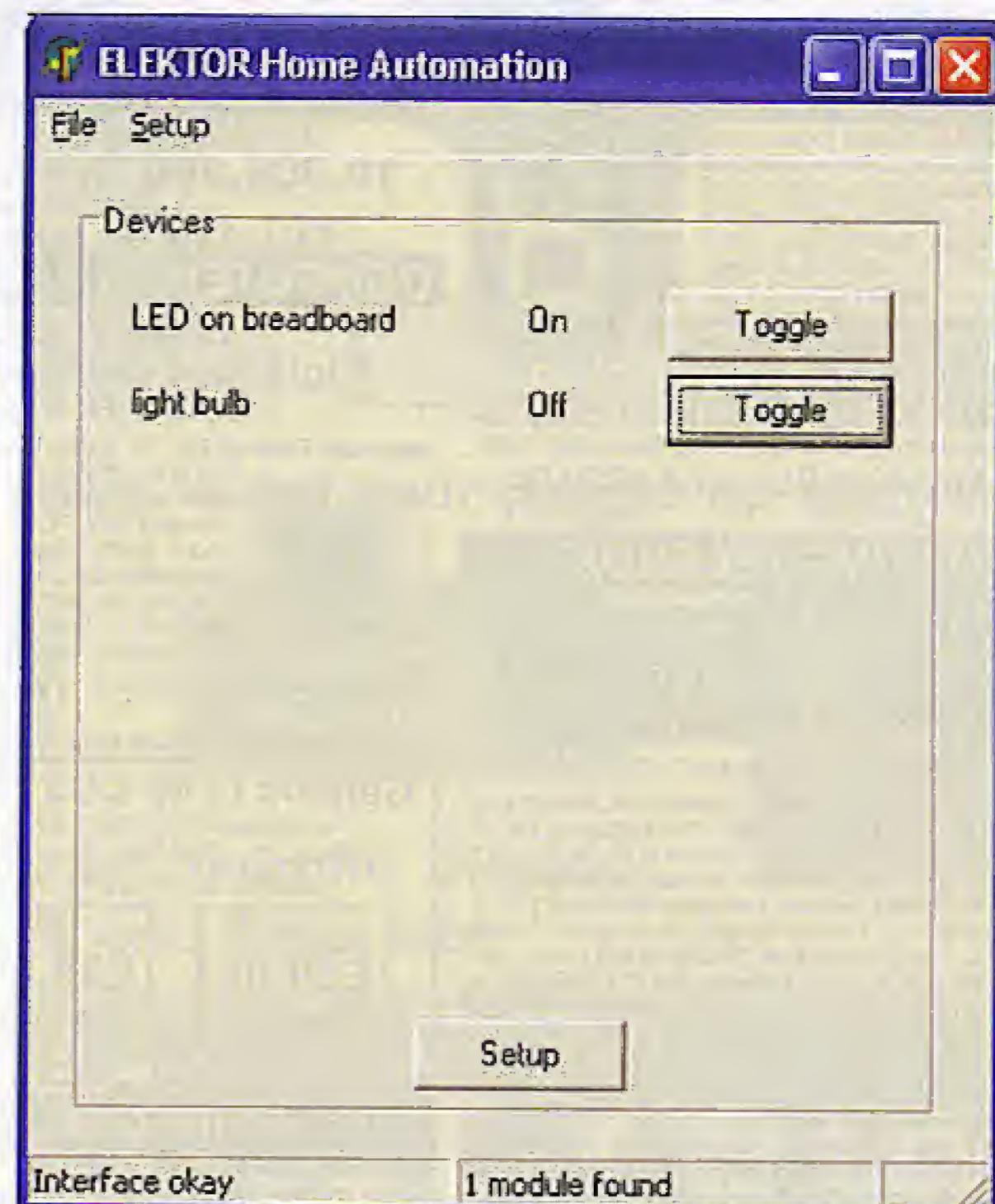
The mains appliance socket fitted in the case has to be fitted separately, as the fuse shown in the circuit diagram only protects the mains transformer. Fused IEC appliance sockets are easily found.

Once the board is populated, you need to check if the logic is properly isolated from the mains. This is best done by measuring the resistance between logic ground and both mains wires (Live and Neutral). Do not connect the circuit to the I<sup>2</sup>C bus until the results of these isolation tests are satisfactory.

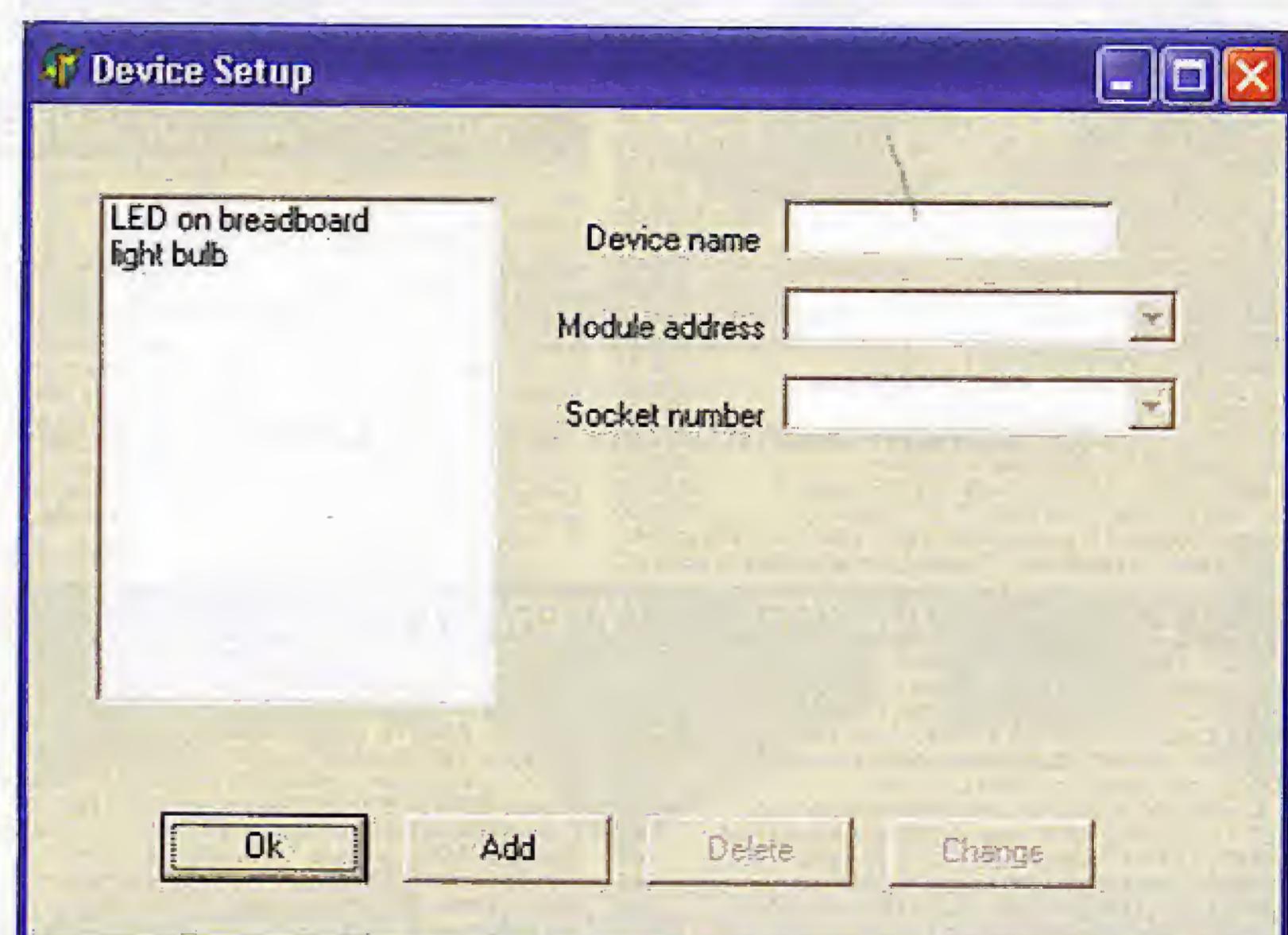
## Software

In order to enable you to get cracking with the USB/I<sup>2</sup>C interface and one or more 'device' modules without having to do your own programming, we've written a small Windows program that allows module outputs to be controlled easily just using the mouse. This program not only verifies the proper operation of the hardware but also forms a good starting point for your own experiments in programming.

The main window shows an overview of selected outputs with associated names, with switches to the right of them. The setup window allows one of the connected circuits to be selected (including the test circuit with the



*Figure 3. This little program allows a simple mouse click to control any individual module output.*



USB/I<sup>2</sup>C interface) and subsequently add any number outputs to the 'switch list' as well as tag them with a name. The name tags then show up in the overview seen in the main window. Both the executable program and the Delphi source code file are available free of charge from the Free Downloads section of our website.

The actual use of the modules in or around your home is left to your imagination and personal requirements. In

any case, there should be plenty of possibilities — for a start, you could automate the coffee machine. However, do make sure manual control is also possible, else your project will be depreciated (to say the least) by your housemates.

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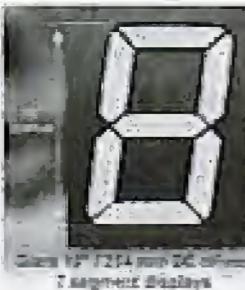
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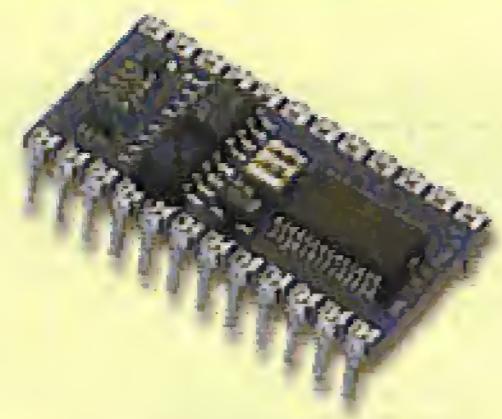
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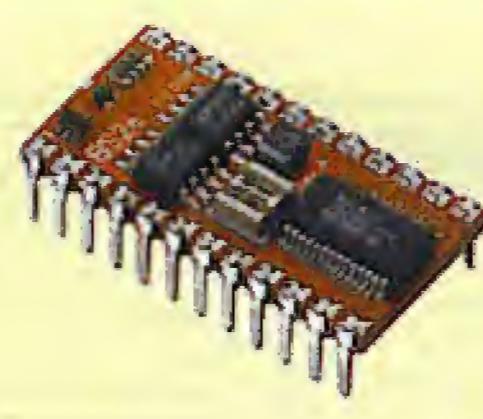
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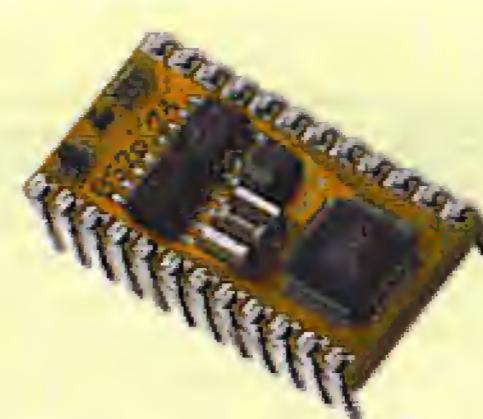
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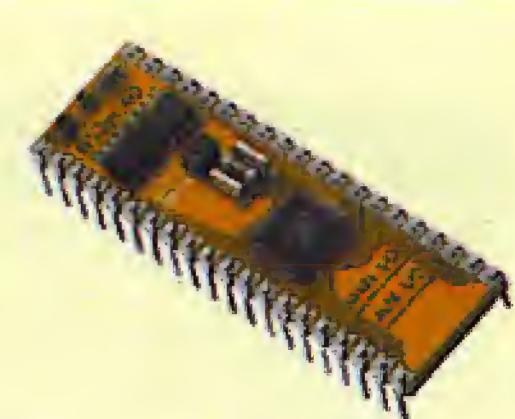
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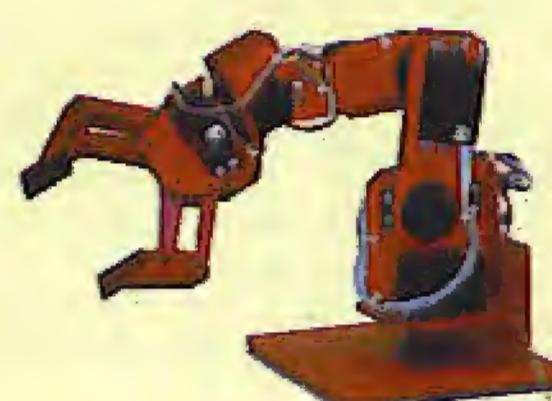
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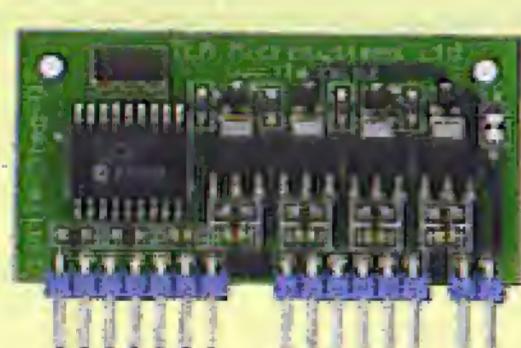


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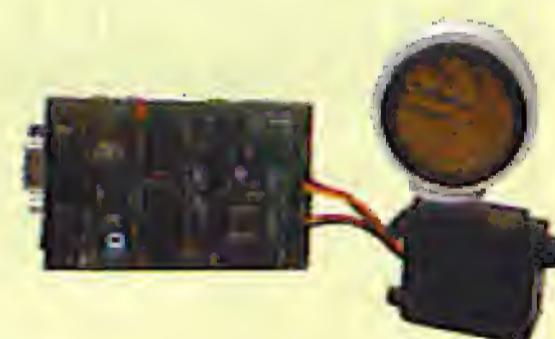
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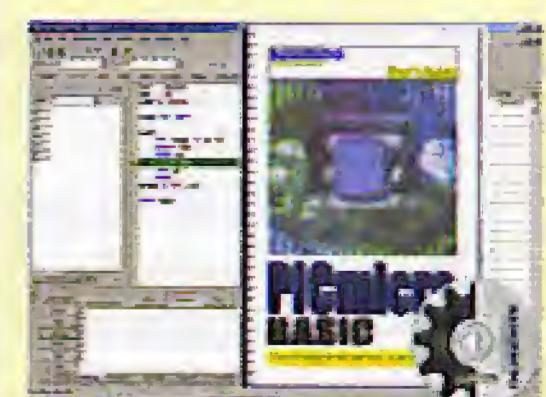


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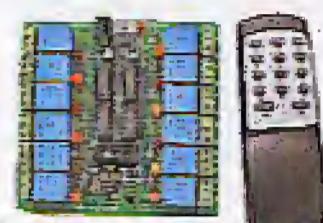
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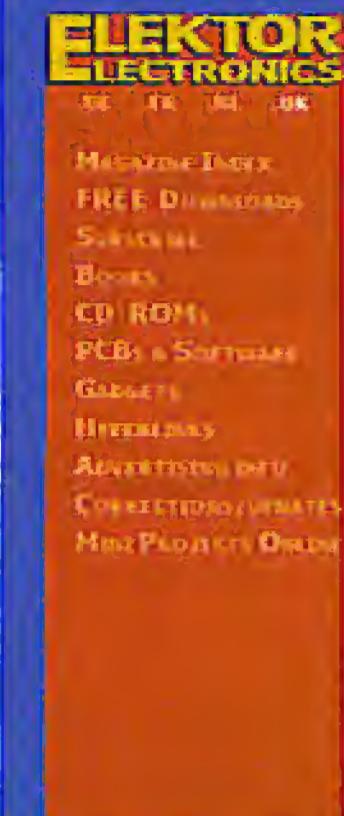
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## Heathkit TC-2P Tube Checker

Jan Buiting

I came across this gem in an unexpected place, namely a flea market for vintage motorcycle parts! Standing between heaps of pistons, wheels and engine parts, the owner claimed it was "some kind of electrical instrument" capable of testing "well, a lot of things I guess". When the small case was opened I immediately recognised a Heathkit tube tester that had definitely seen better days.

Once I had intimated to the owner that I had no idea what the instrument was actually supposed to do, plus that it was ramshackle, grimy, grossly incomplete and so on, I paid 10 pounds, closed the lid and walked away in exuberance.

### Rising damp

My TC-2P (build: approx. 1962) was badly affected by moisture, probably as a result of having been stored in a damp cellar for years. The control panel had large blots of what looked like calcium deposits. Fortunately, these were easy to remove by

first loosening them up with a soft toothbrush and then rubbing with just a touch of car wax. I purposely left one area untouched. All knobs and the moving coil meter were removed and the control panel lacquer soon appeared in all its former glory. On the inside, however, more serious problems were seen. The mains cord (110 VAC) had gone as crusty as cornflakes and was now a real hazard. The same for the tiny power on/off slide switch which was totally blocked by white stuff. All easy to clean and repair, however.

The most troublesome part was the moving-coil meter, of which the needle appeared to be stuck. On closer inspection I discovered that the meter's anchor/coil assembly (a wonder of precision assembly), had been eaten way by corrosion hence was beyond repair. An alternative was found in the use of another vintage 1-mA meter from which I removed the scale plate, replacing it with the still intact Heathkit plate with its delightfully simple **BAD - ? - GOOD** print. Having drilled four holes in the control panel I mounted the 'new' meter. It worked a treat.

The wheel-operated tube selection chart in Heathkit tube testers

is a notorious item because it is easily damaged by all too frequent as well as infrequent use! In my case, the part of the chart that had been horizontal for years had dried up and gone so rigid it was in danger of rupturing when I attempted to turn the wheel. The chart was disassembled; rolled off and on again; creases and a small tear were repaired. Today it can be turned again but not to the extremes. This problem was solved by downloading the chart from the Internet and referring to printed pages to find the various settings for a specific tube I want to test. This also allows me to use updates of the chart for later (post-1965) tube types.

### Practical use

In the mid 1970s, a friend and fellow radio amateur occasionally allowed me to use his mighty TT-1 tube checker to see which tubes in my collection were still any good! As it turned out, preciously few!

Working with a tube tester soon becomes second nature. Using the rolling chart, finding the pin-out codes and moving the controls and levers to match the tube you want to test needs to be done with care, else you get very strange

results when the TEST switch is finally pulled down! Most people will at least smile when I demonstrate the TC-2 testing the 'quality' of a couple of tubes plugged into the various sockets and then watching the meter indication — youngsters are bewildered if you test a large tube like the 807. The TC-2 Assembly and Operation Manual is a fine example of no-frills US-style instructions on kit assembly at home. I have no idea how many TC-2's were sold but the occasional look at Ebay USA tells me a genuine TC-2P is a rare find at the price I paid.

*Anyone have a set of spare plastic caps for the lever switches?*

(045006-1)

### Web pointers

[www.jogis-roehrenbude.de/](http://www.jogis-roehrenbude.de/)  
[Roehren-Geschichtliches/Roe-Pruefer/Heathkit-TC-2/](http://Roehren-Geschichtliches/Roe-Pruefer/Heathkit-TC-2/)  
[Heath-TC-2.htm](http://Heath-TC-2.htm)

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Retronics is a monthly column covering vintage electronics including legendary Elektor designs. Contributions, suggestions and requests are welcomed; please send an email to [editor@elektor-electronics.co.uk](mailto:editor@elektor-electronics.co.uk), subject: Retronics EE.

# Continuous Flow Soldering

From reader correspondence we know that lots of you are still hesitant about soldering SMDs (surface-mount devices), particularly integrated circuits.

We won't say it's a piece of cake, but maintain that there's no reason to start panicking about SMDs, as accurate soldering does the trick. Using the right tools and some basic skills, soldering SMD ICs with 'gullwing' or 'J' leads should be within your reach.

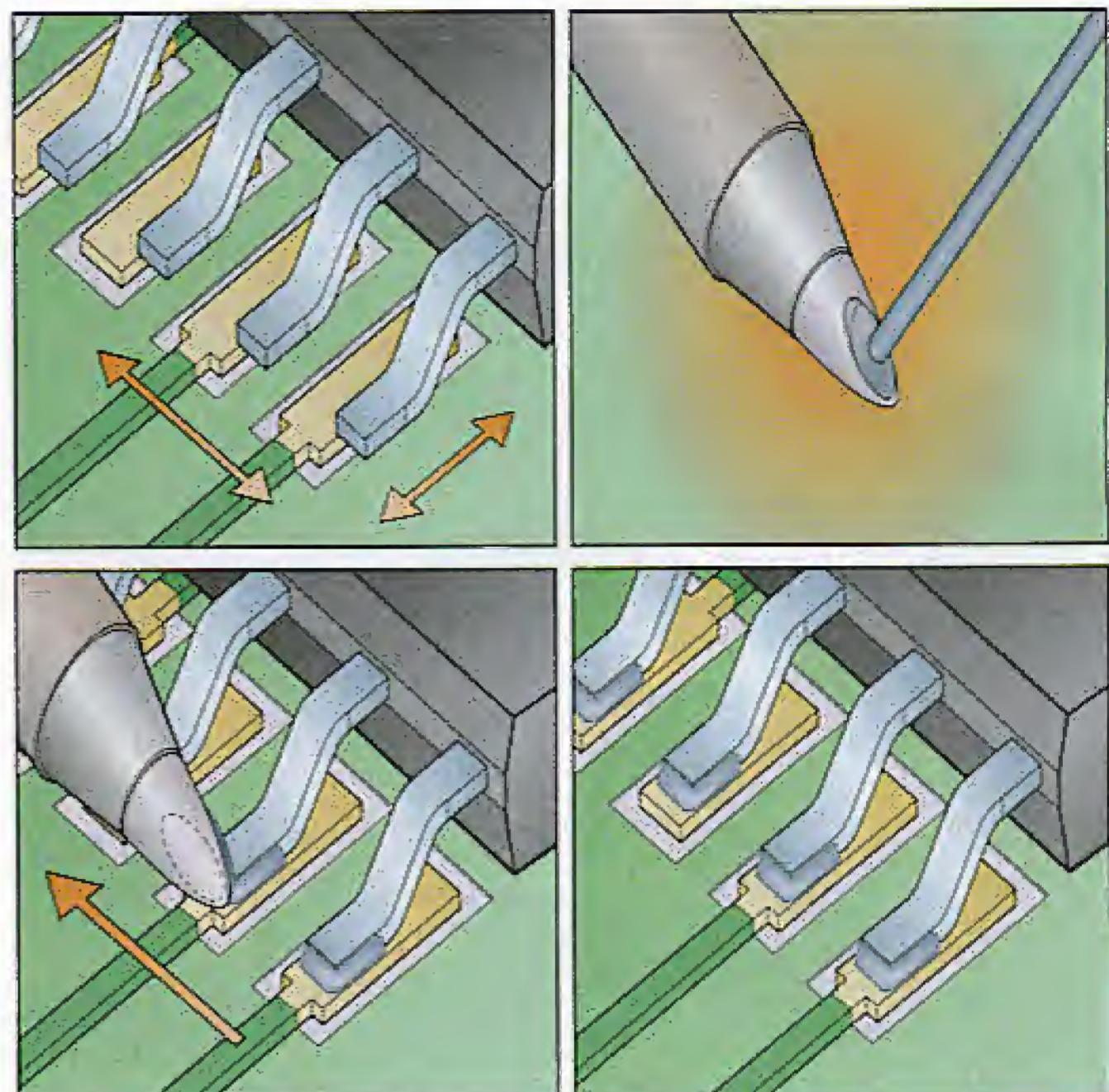
#### What's needed

In any case, make sure sufficient solder flux (flow agent) is available, so that the liquefied solder will easily flow towards the desired solder pad instead of to creep up adjacent pins or fill unwanted holes! Small pieces of cloth and flux cleaner are also recommended to mop up solder spills. The actual soldering is best done using an iron with a so-called 'wave' tip. This tip has a hollow part capable of holding an amount of liquid solder. Finally, we would recommend the

use of an illuminated desktop magnifying lamp.

#### What to do

1. Apply flux to the copper pads in the corners of the IC footprint.
2. Put the IC on the footprint, carefully aligning the pins at diagonal corners with the solder pads.
3. Place the wave tip on the junction between the IC pin and the pad in one of the corners. If necessary add some solder flux.
4. Remove the tip. Wait for the solder to solidify. Next, solder the opposite solder pin.
5. Put some solder in the wave tip to create a 'bead'.
6. Hold the solder tip such that the bead is in contact with the upper surface of the IC pins. Slowly, in one smooth movement, move the solder tip



across the contact row, such that a uniform amount of solder is applied to each pin.

7. Repeat step 5 and 6 for the other side(s) of the IC.
8. If necessary clean and inspect the result.

The above method may also be applied to ICs with 'J' leads.

#### Background

For clarity's sake: the advantage of the proposed method is that you do not have to add solder to the tip for each IC pin. The dispensing of solder from the 'bath' in the solder tip is based on a principle from physics called 'capillary action'. Because every solder pad/pin surface ratio is identical, each contact will attract an identical amount of solder, the excess amount being retracted by the solder tip. In addition, solder is attracted by a heat source, in this

case, the solder tip.

The above process only works if sufficient flux is present on the solder pads. After all, solder does nothing except melt during heating. For best results, however, it should flow and bond, too.

Copper, tin and lead are 'porous' metals that protect themselves from corrosion by forming a thin oxide layer. Agents like solder flux have an etching effect that removes oxide layers.

It is recommended to use solder fluxes based on resin, as they are the easiest to remove using (inexpensive) flux cleaners based on alcohol.

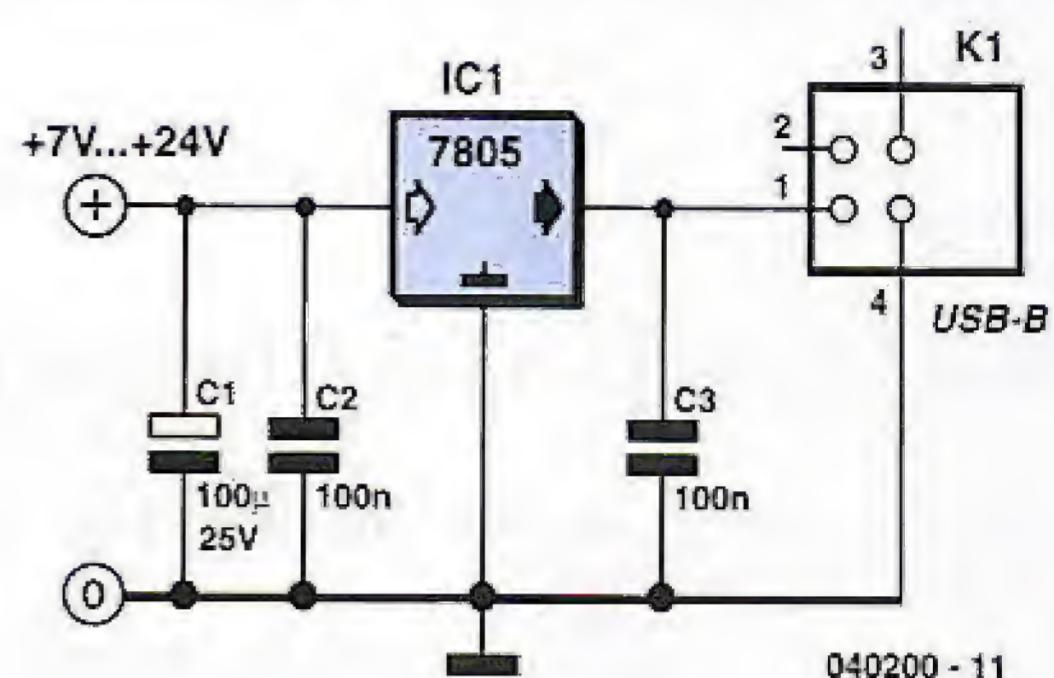
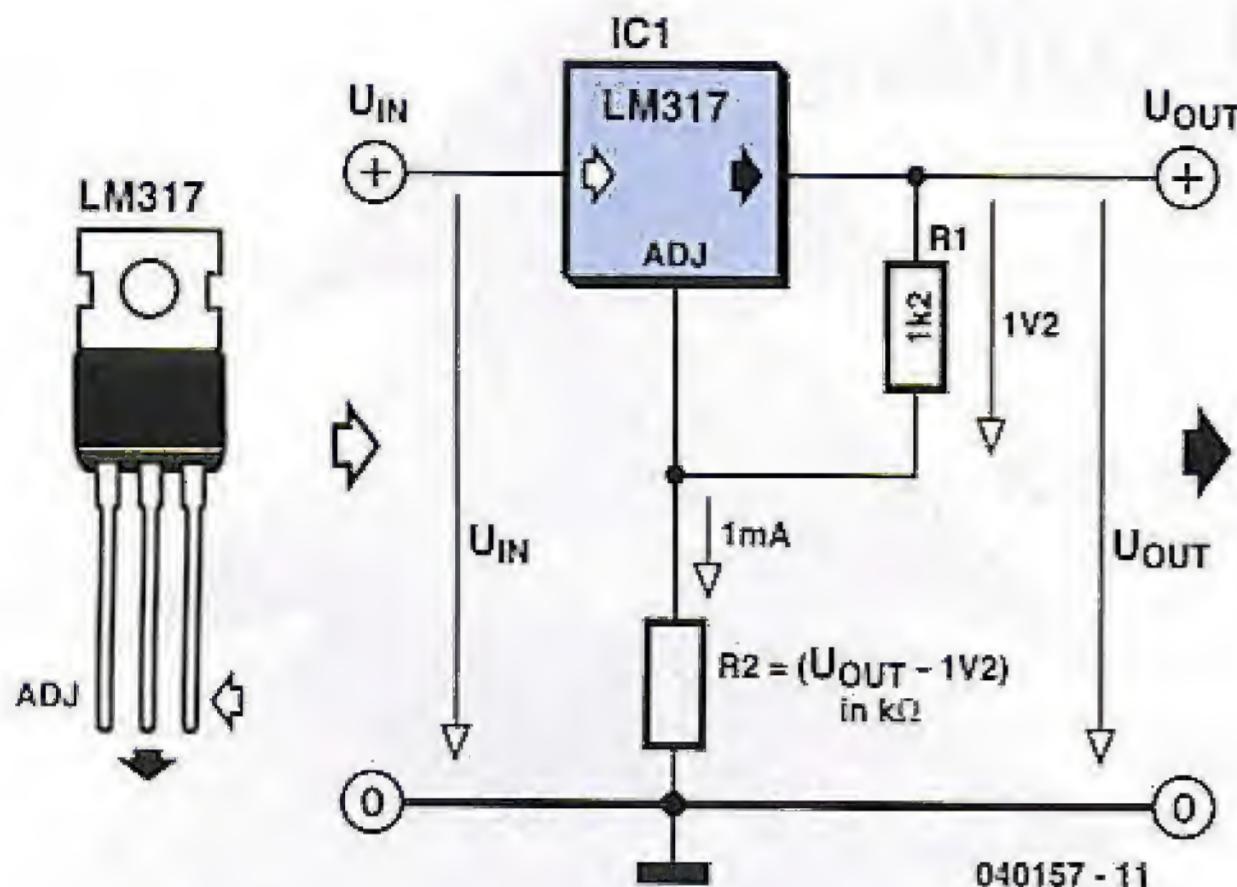
Solder iron tips for continuous flow soldering are produced by, among others, JBC, Xytronic, Metcal, Weller and Pace.

(G40323-1)

**Illustrations:**  
courtesy Circuit Technology Center.

**The internet site for all professionals and hobbyists  
actively engaged in electronics and computer technology**

**www.elektor-electronics.co.uk**



## Voltage regulator calculation

Victor Himpe

Before you can design an adjustable voltage regulator into your circuit, or do a redesign, you need to calculate the values for two resistors. This is not difficult in itself, but actually finding the right resistors may pose problems. Fortunately a trick is available to make it all much easier. With most adjustable voltage regulators like the LM317 and LM337, the input voltage has to be 1.2 to 1.25 volts above the desired output voltage. This is because the voltage at the ADJ (adjust) input is internally compared to a reference voltage with that value.

The reference voltage always exists across R1. Together with preset R2 it determines the current flowing through the ADJ pin, as follows:

$$V_{out} = V_{REF} [1 + (R2/R1)] + I_{ADJ} R2$$

If for the sake of convenience we ignore  $I_{ADJ}$ , enter the reference voltage (1.2 V) and for R1 select a value of one thousand times that voltage (i.e., 1.2 kΩ) then the equation is simplified to:

$$R2 = 1000 (V_{out} - 1.2)$$

In practice, simply determine the voltage drop across R2 (output voltage minus reference voltage) and you get your resistance value directly in kilo-ohms. For example, for 5 V R2 becomes  $5 - 1.2 = 3.8 \text{ k}\Omega$  which is easiest made by connecting 3.3 kΩ and 470 Ω resistors in series. In the case of relatively low voltages, smaller resistor values are recommended. This is because sufficient current needs to flow to enable the voltage regulator to do its job. A simple solution is to choose, say, 120 Ω for R1. R2 then becomes:

$$R2 = 100 (V_{out} - 1.2)$$

(040157-1)

## Power Supply for USB Devices

Roman Mittermayr

More and more equipment is sold that runs off internal rechargeable batteries. Although a matching charger is usually supplied in the package, there are also devices that can only be charged via a USB port. That is not surprising in the case of USB MP3 players, which have to 'dock' in the PC anyway for some time for the purpose of file transferring. Still, the same 'feature' can be a serious disadvantage, for example, on 'computer-free' holidays.

Sometimes it makes you wonder how simple the solutions to such problems actually turn out to be. After all, if it's just a supply voltage we're after, then a USB port is easily imitated.

The circuit shown here is nothing but a 7805 in a dead standard configuration. The innovation, if any, might be USB connector to which the MP3 player can be connected.

The 7805 comes in different flavours — most devices can supply 1 A, but there are also more advanced variants that achieve up to 1.5 A. Because a USB device is never allowed to draw more than 500 mA from the port

it is plugged into, the circuit shown here should be able to supply charging and/or operating current to up to two (or three) USB devices at the same time. The input voltage may be a direct voltage of anything between 7 and 24 volts, so for use at home or abroad a simple wall cube with DC output is sufficient. Another useful bit to make yourself might be a cable with an inline fuse and a cigarette lighter plug so you can tap into a vehicle supply (note that this may be up to 14.4 V with a running engine).

At an output current of 1 A and an input voltage of just 7 V, the 7805 already dissipates 2 watts. Assuming you're using the most commonly seen version of the 7805, the TO-220 case with its metal tab will have a thermal resistance of about 50 °C/W. Also assuming that the ambient temperature is 20 °C, the 7805's internal (chip) temperature will be around 120 °C. In most cases, 150 °C is the specified maximum, so ample cooling must be provided especially in a car and with relatively high input voltages.

(040200-1)

# LED CHRISTMAS TREE

## Plus additional seasonal circuits...

This flashing LED mini Christmas tree is not only dead simple to build but the design is also repeatable and very reliable in operation. In fact an ideal last-minute project to brighten up the house or office in the run-up to Christmas.



It can sometimes be satisfying for the electronics enthusiast to build something that adds a personal touch to a special occasion. The mini Christmas tree design described here fits the bill and should strike a suitably festive note. This particular flashing Christmas decoration cannot be purchased ready made but needs instead to be assembled. The circuit design is just about as bullet-proof as is possible using a PCB, battery and just a few components. It is aimed at the less experienced constructor.

Those of you who would like to try their hand at alternative seasonal projects may be interested in some additional circuits that have been made available for free download this month from the *Elektor Electronics* website at [www.elektor-electronics.co.uk](http://www.elektor-electronics.co.uk) (see editor's footnote at the end of this article).

### So simple

The circuit for the Christmas tree project is ideal for the complete electronics

novice. The same circuit was used for various flashing ornaments that were built from kits of parts at our *Elektor Electronics* exhibition stand recently. Even five-year olds were seen successfully assembling and soldering the parts together to produce working kits in less than 30 minutes!

The circuit in **Figure 1** is about as simple as it gets. A single IC, two resistors, one capacitor and eleven LEDs comprise the total circuit. LEDs were used here because they consume less power than filament lamps and are also far more reliable.

The circuit will run for 48 hours on end from a fresh 9-V alkaline battery, so a single battery should last you through the whole Christmas week if it is only used in the evening.

The IC is a CMOS 4060 oscillator/divider with ten outputs. The oscillator operating frequency depends on the values of C1, R1 and R2 and should be approximately 2 Hz with the component values given. The outputs Q3 to Q9 and Q11 to Q13 switch at the oscillator frequency.

The LEDs are wired so that it looks like they are switching in a random manner but if you study the LEDs a bit more closely you will notice that there are always three LEDs lit at any one time.

### Soldering

The PCB layout shown in **Figure 2** is already cut into a Christmas tree shape. Component placement and soldering should not present too much of a problem so long as you study the layout closely. It is important to fit the LEDs the correct way round (remember, the shorter or cut lead is the anode). An IC socket is used to fit IC1 to the PCB. Ensure that the socket is the correct way round before it is soldered to the PCB and that the IC is correctly orientated before it is pushed into the socket (a 'pip' on the package always indicates pin 1).

Once all the components have been fitted solder the battery clip leads to the PCB. The red lead is soldered to the positive (+) pad and the black lead to

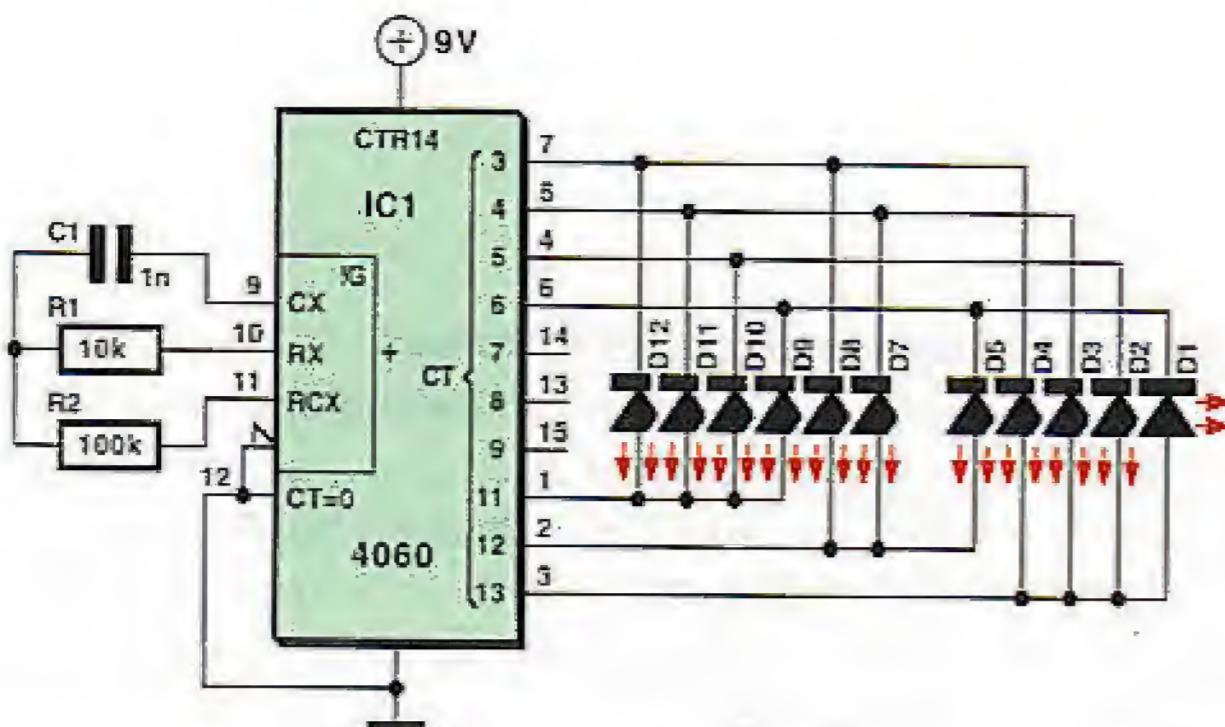


Figure 1. The LED Christmas tree circuit really has been tried and tested a thousand times!

the negative (-) pad. The battery clip contacts are pushed through the two holes at the foot of the tree so that the battery can be fitted to the other side and acts as a stand for the tree. If

everything has gone to plan the LEDs should start to twinkle once the battery is connected.

**Merry Christmas!**

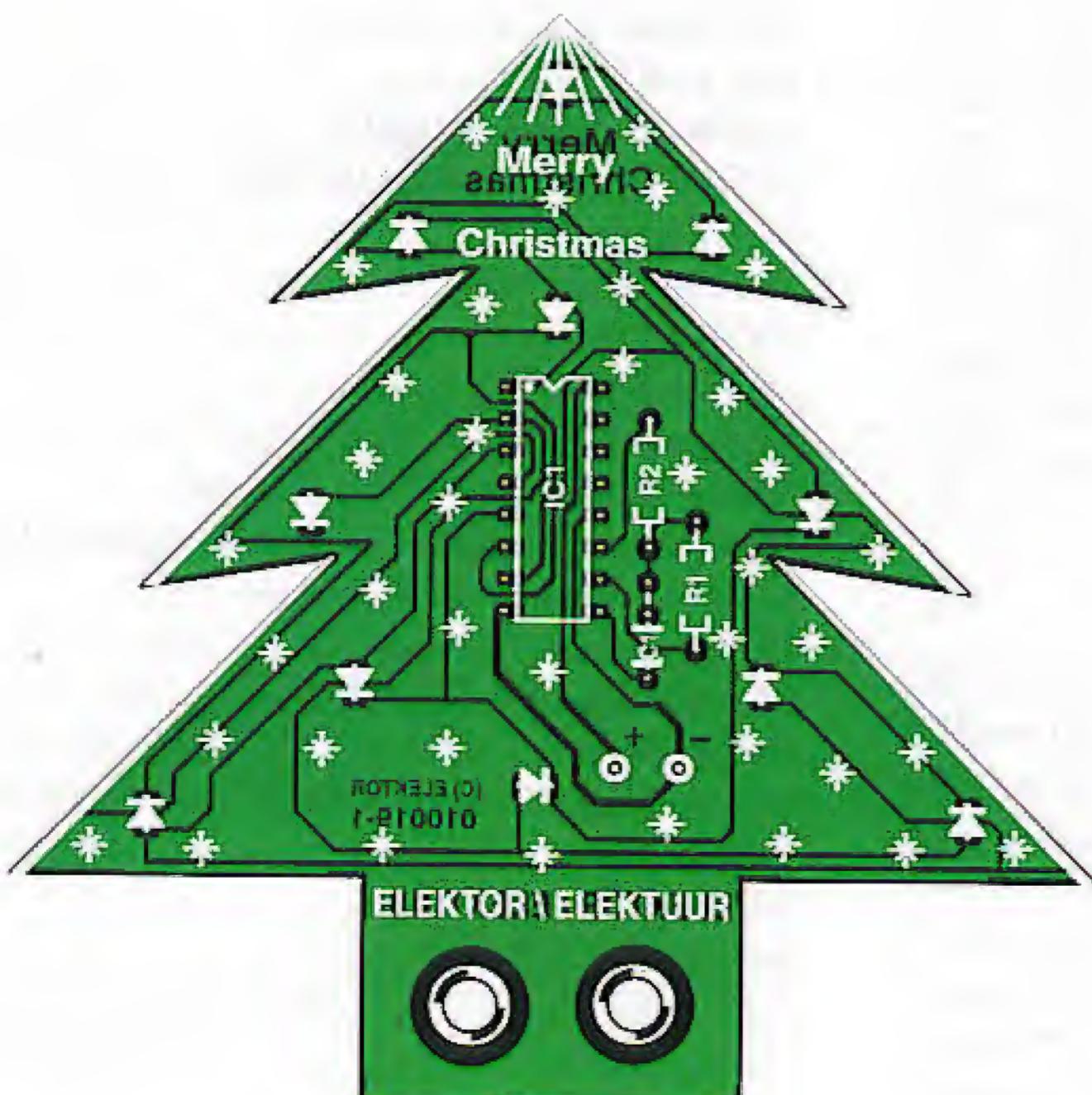


Figure 2. The mini Christmas tree component placement.

## COMPONENTS LIST

### Resistors:

R1 = 10k\_ (black-brown-orange)  
R2 = 100k\_ (black-brown-yellow)

### Capacitor:

C1 = 1nF

### Semiconductors:

D1-D12 = LED, low current (all colours possible except white)  
IC1 = 4060

### Miscellaneous:

16-way DIL socket for IC1  
9-V (PP3/6F22) battery with clip

Kit of PCB & parts, order code  
**010019-91**

## Free Christmas circuits from [www.elektor-electronics.co.uk](http://www.elektor-electronics.co.uk)

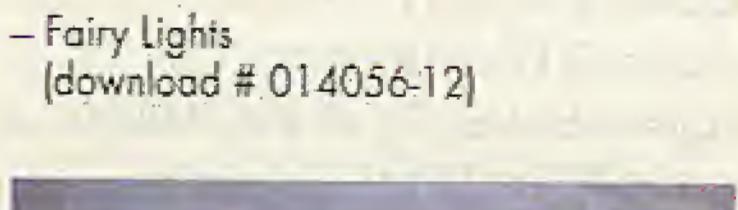
We are truly getting the festive spirit at [www.elektor-electronics.co.uk](http://www.elektor-electronics.co.uk) where you will find five Christmas circuit designs that are available for free downloading. Each circuit includes a PCB layout and, if applicable, software listings:



– Flashing Christmas Star  
(download # 990074-12)



– An Electronic Bell  
(download # 000116-12)



– Fairy Lights  
(download # 014056-12)



– A Star for Christmas  
(download # 020040-12)



– LED Christmas Decoration  
(download # 030157-12)

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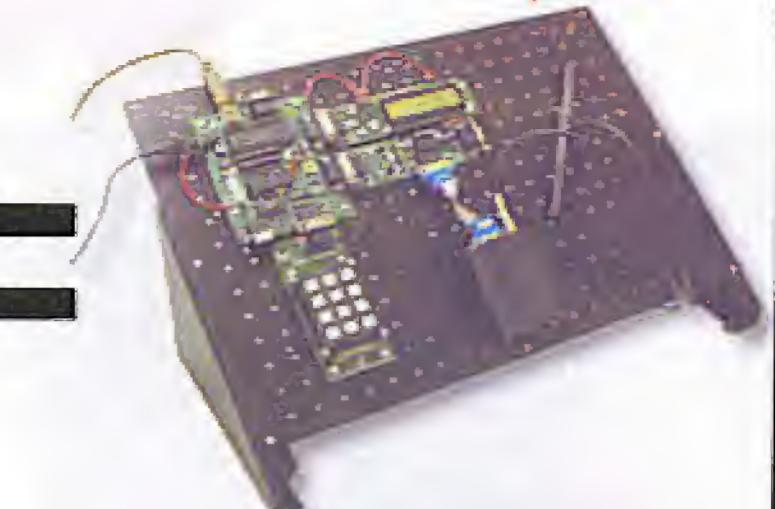
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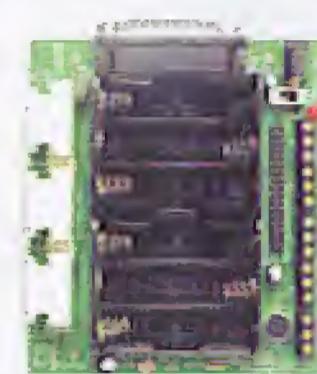
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## ECD (Edition 2)

### Elektor's Components Database

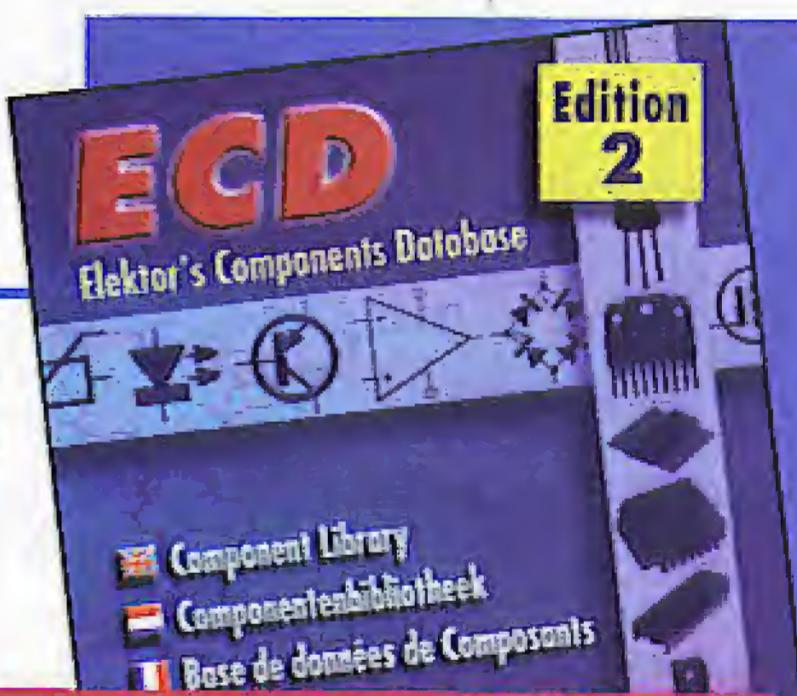
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# QUIZZ'AWAY



Professor Ohsmann in e-magician's disguise during his Christmas lecture when the 'Wond'rous Light Chain' was first demonstrated.

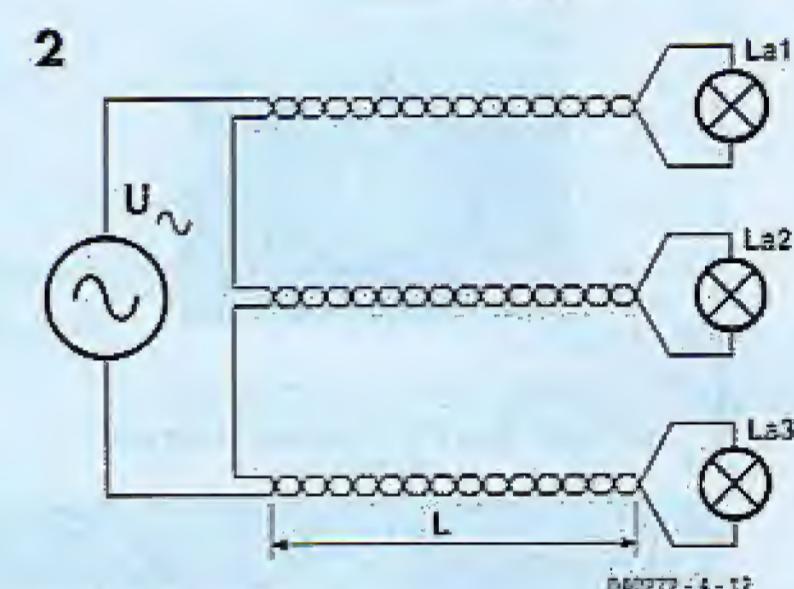
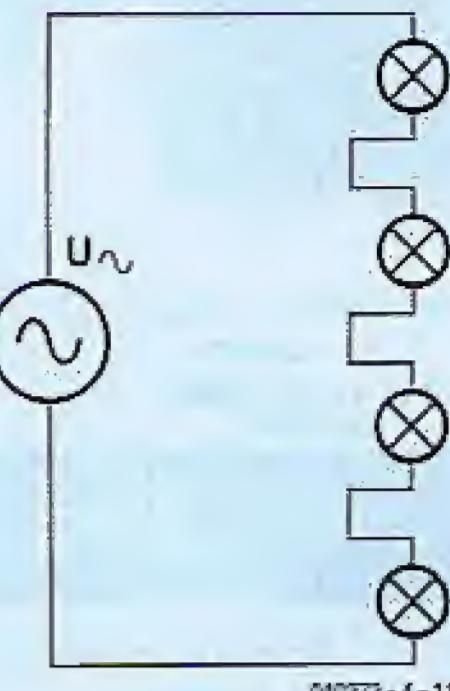
## Wond'rous Light Chain

With the Festive Season upon us, it seems fitting to devote this month's Quizz'away installment to the perennial problems associated with Christmas tree lighting. Conventionally, lamps are connected in series (**Figure 1**) and this immediately creates a problem: when one lamp fails, it breaks the series network and all other lamps will also go out. But that's not all, because in the dark you will have hard time finding the defective lamp in the first place. A solution to this problem could be to simply wire up the lamps as shown in **Figure 2**.

Let's assume each lamp is powered by way of a cable with a length  $L$  of 4.5 m. Twisted-pair wires from Ethernet cables are used because of their attractive colours. Close to the power supply, the cable ends are connected in series again. A photograph of the practical version is shown in **Figure 3**. Normal lamps rated at 12 V, 0.1 A are used.

So far so good; let's connect the lot to a suitable 36 VAC power supply. This time, much to everyone's surprise, failure or removal of one lamp does not cause overall darkness — all other lamps in the Wond'rous Light Chain remain on and even light a little brighter! In this manner, the total brightness remains almost constant and the Christmas festivities are not spoilt, plus you will be able to easily spot the faulty lamp.

**Can you explain what is happening?**



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Please send your answer to this month's Quizz'away problem, by email, fax or letter to:

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**The closing date is  
22 December 2004**

(solution published in February 2005 issue). The outcome of the quiz is final. The quiz is not open to employees of Segment b.v., its business partners and/or associated publishing houses.

*As of the September 2004 issue Quizz'away is a regular feature in Elektor Electronics.  
The problems to solve are supplied by Professor Martin Ohsmann of Aachen Technical University.*

## Solution to the October 2004 problem (p. 79; very high gain two-stage transistor amplifier)

The circuit diagram clearly shows that the first transistor is operated in common-emitter configuration. The second transistor is operated in common-collector mode hence does not contribute to the voltage gain.

By approximation, the voltage gain equals the product of T1's slope (in biased configuration) and its operating resistance. The slope (or transconductance)  $S$  is proportional to the collector resistance. For a high voltage amplification  $A$ , a high collector current and a high operating resistance are required. In the classical circuit, the above product is the voltage drop across the collector resistor and therefore limited by the supply voltage. Typically, the collector will be at half the supply voltage. Dividing it by the thermal voltage  $U_T = 26 \text{ mV}$  results in a maximum amplification  $A = 6 \text{ V} / 26 \text{ mV} = 230$ .

Here the circuit leaves the beaten track, the second stage acting as the operating resistance, i.e., presenting a (virtually) constant-current load to the first transistor. The crux is resistor R4 which takes an unusually small value. Because its base voltage is an almost constant 0.7 V, T2 keeps the voltage drop across R4 virtually constant. The current through R4 so determines T1's collector current at about  $0.7 \text{ V} / 4.7 \text{ k}$

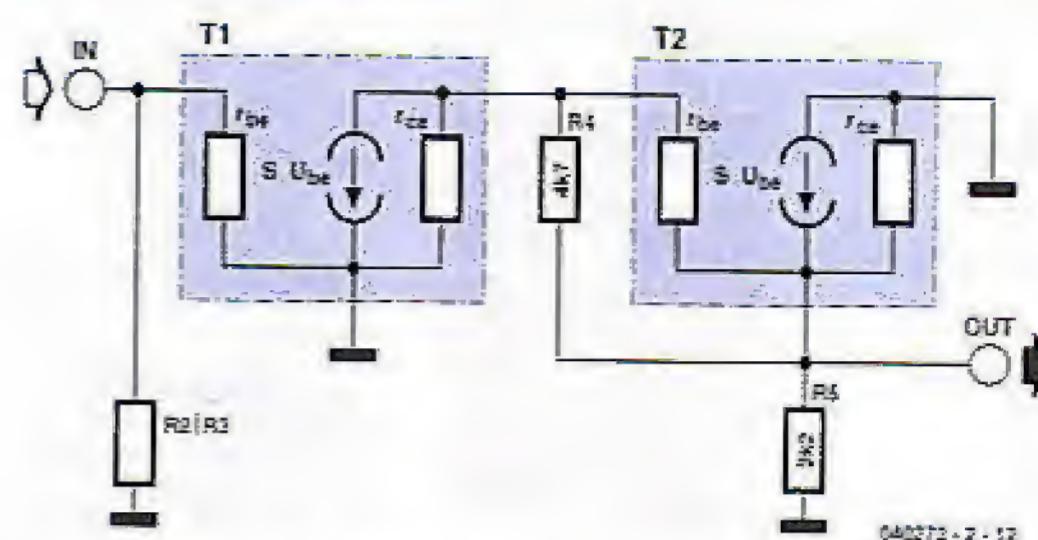


Figure 4. Small-signal equivalent circuit.

$= 150 \mu\text{A}$  independent of the input signal. In this way, the second stage forms a very high-impedance load that, unlike a fixed resistor, will allow a relatively high collector current to flow. In order to arrive at a quantitative result, we have to calculate the internal resistance of the load. This requires looking at it in greater detail and accounting for the small-signal resistances of the transistors operating at their biasing points. The diagram in **Figure 4** shows the small-signal equivalent circuit comprising all relevant components. Resistor  $R_4 = 4k7$  is in parallel with  $T_2$ 's base-emitter resistance  $r_{BE} \approx 2k5$ .  $T_2$ 's gain is just below unity (in this case,  $1 - 1/250 = 0.996$ ), so that the input resistance of the second stage is about 250 times  $R_4 // r_{BE}$ , which works out at about  $400 \text{ k}\Omega$ . The internal resistance of the second stage is effectively in par-

allel with the output resistance  $r_{CE} \approx 1 \text{ M}\Omega$  of the first stage. The result is that  $T_1$  sees a small-signal operating resistance of  $1 \text{ M}\Omega // 400 \text{ k}\Omega$  or about  $300 \text{ k}\Omega$ . Now we can calculate the slope  $S$  of  $T_1$  as

$$S = I_C / U_T = 150 \mu\text{A} / 26 \text{ mV}$$

$$S = 0.0058 \Omega^{-1}$$

hence

$$A = 300 \text{ k}\Omega \times 0.0058 = 1740$$

which is quite close to the measured value of 1800.

### Source:

James D. Keith,  
The 'Starved-Circuit' Amplifier is  
revived in a transistor version,  
*Electronic Design* April 2001, pp. 131.

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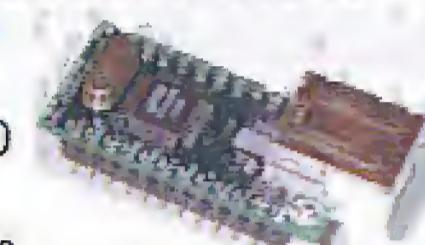


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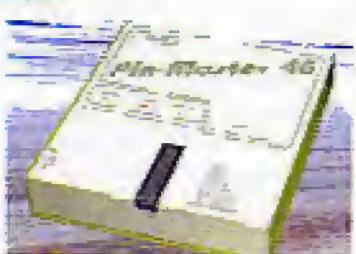
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### Cuk Converter

The Cuk converter is a type of electrical inverter converting power at one DC voltage to power at a different voltage. Unlike most other types of converter which use an inductor, it employs a capacitor as its main energy-storage component. The converter is named after Slobodan M. Cuk of the California Institute of Technology, who first presented the design in the early 1990s.

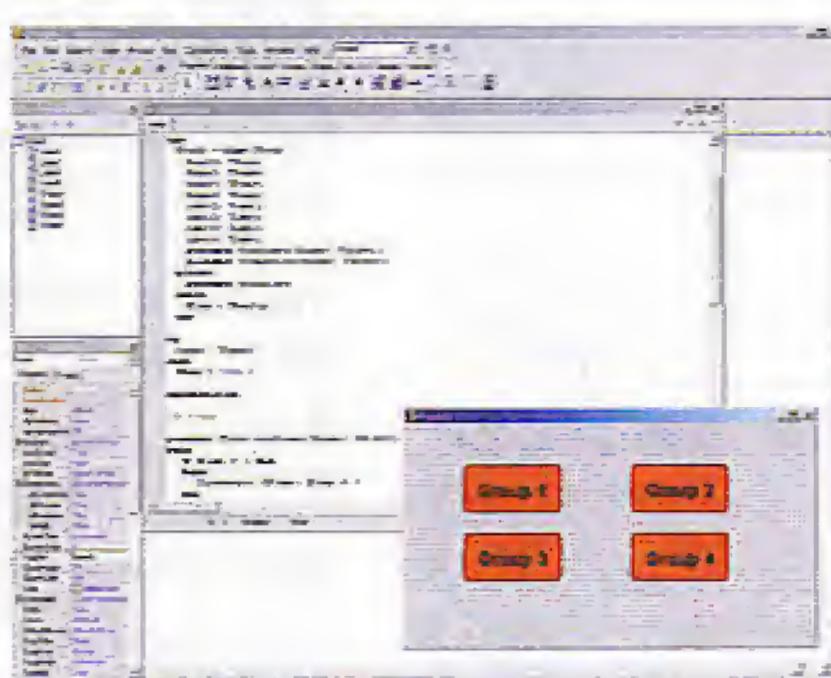
In good Elektor tradition we describe the theory as well as a practical design in the form of an adjustable 0-50V, 0-5A power supply unit. This project was previously announced for publication in the November 2004 issue. It was moved to the January 2005 magazine to fit in with the theme of the month: Power Supplies.

### ATX PSU Tester

PC power supplies come at an excellent price/performance ratio, especially when supplied as spare parts (NOS — new old stock). However, before actually using the replacement PSU you will want to be sure it works. The tester we've designed for that purpose excels in ease of use. All ATX PSU output voltages are checked under 'loaded' conditions and the results are displayed on six LEDs for a quick Go/Non-Go indication. Optionally, the exact test results may be viewed on an external LC display.

### The Road to Delphi (1)

In the January 2005 we launch a new course on practical use of the Delphi higher programming language for hardware control. For example, we describe in detail how a Delphi program is written on a Windows PC and subsequently transferred to a microcontroller to enable it to run a turnkey application. Further extensive and practice-oriented instalments are planned to form a series of articles you can use as courseware.



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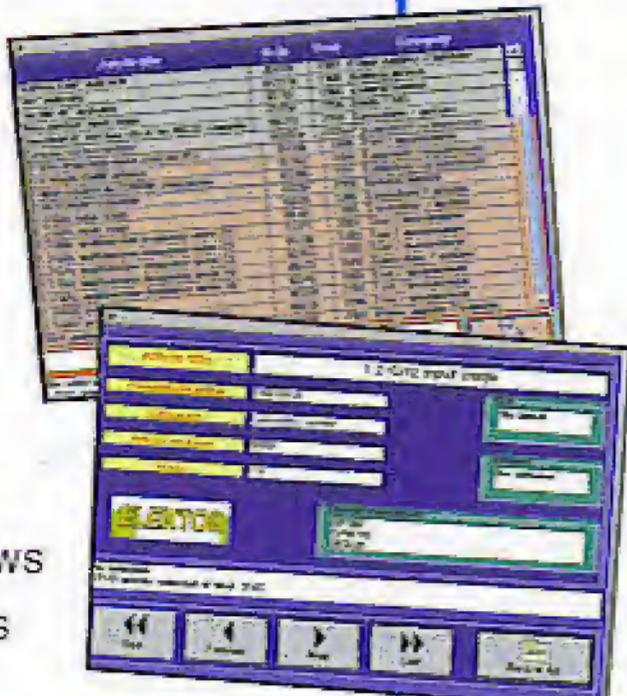
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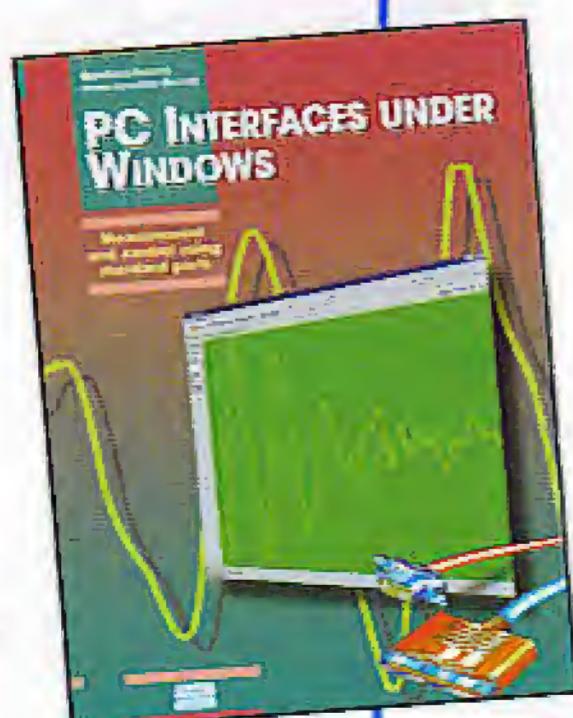
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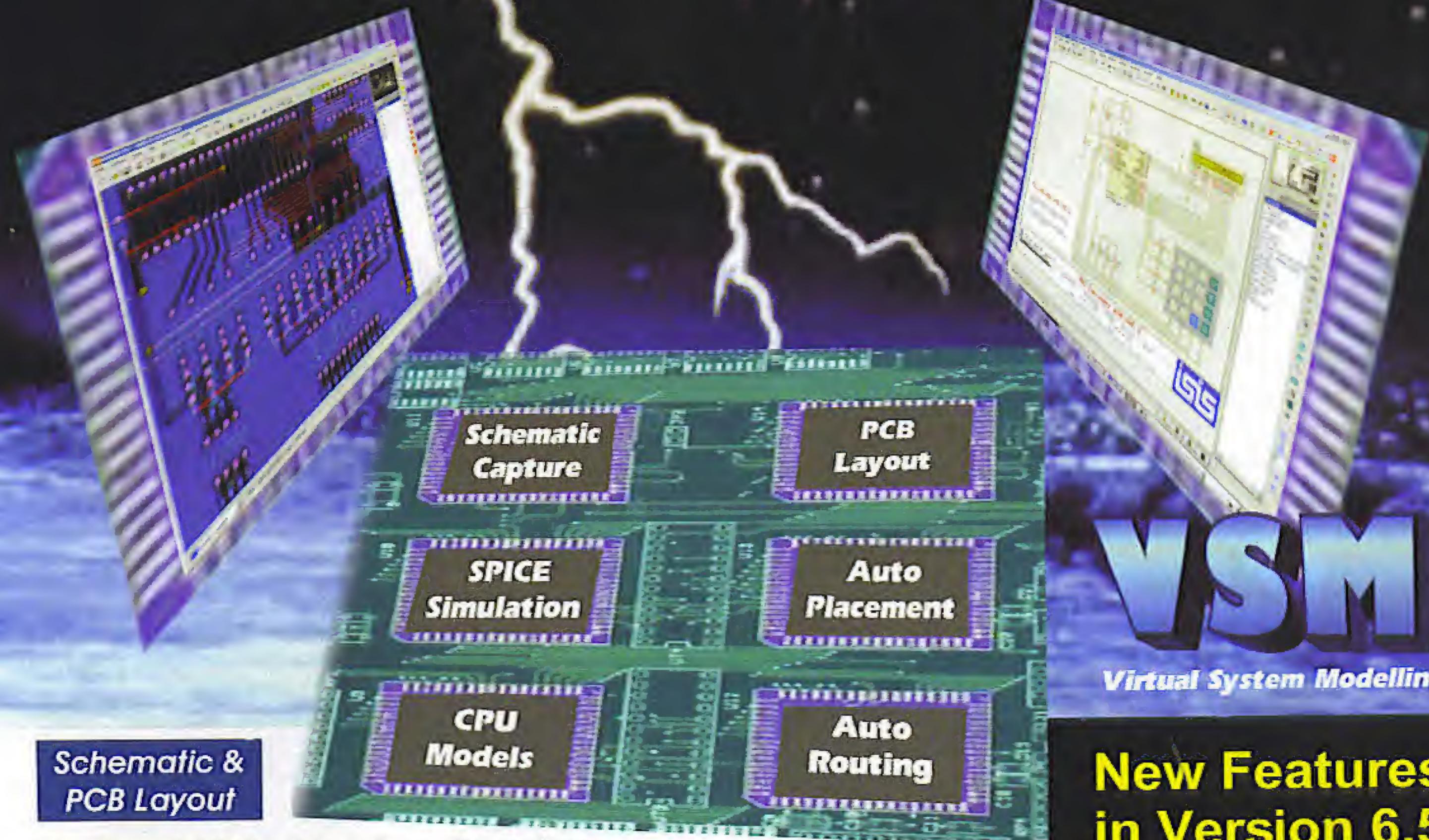


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